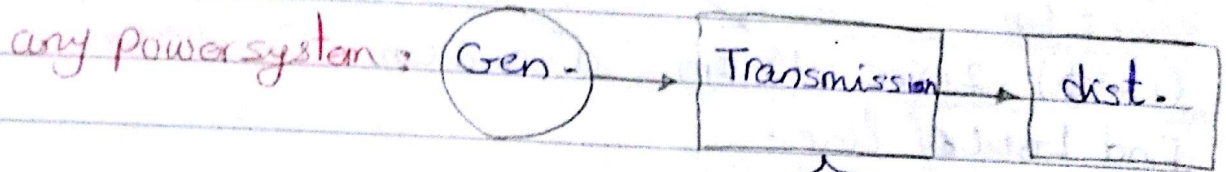


# POWER system



Cables

T-L

كابل

خطوط

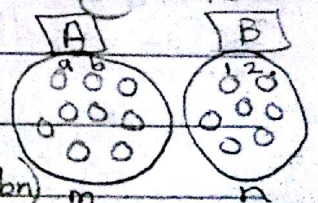
inductance

$$L = 2 \times 10^{-7} \ln \left( \frac{D}{r} \right) \rightarrow \bar{r} = 0.7788 r \quad \text{H/m}$$

$$L_{\text{Total}} \text{ For two conductors } = 4 \times 10^{-7} \ln \left( \frac{D}{r} \right) \quad \text{H/m}$$

skin effect في الـ stranded

$$\text{For composed: } L = 2 \times 10^{-7} \ln \frac{\text{GMD}}{\text{GMR}}$$



$$\text{GMD} = \sqrt{(D_{a1} D_{a2} \dots D_{an}) (D_{b1} D_{b2} \dots D_{bn}) \dots (D_{m1} D_{m2} \dots D_{mn})}$$

$$\text{GMR}_A = \sqrt{(D_{aa} D_{ab} \dots D_{am}) (D_{bb} D_{ba} \dots D_{bm}) \dots (D_{mm} D_{ma} \dots D_{mn})}$$

$$\Rightarrow D_{aa} = 0.7788 r_a = D_{bb} = D_{cc} \dots = D_{nn}$$

$$\text{GMR}_B = \sqrt{(D_{11} D_{12} \dots D_{1n}) (D_{22} D_{21} \dots D_{2n}) \dots (D_{n1} D_{n2} \dots D_{nn})}$$

$$D_{11} = D_{22} \dots = D_{nn} = 0.778 r_i$$

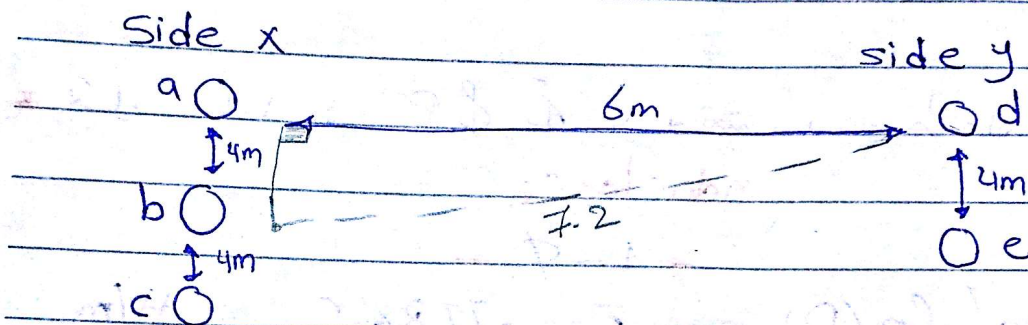


Sheet 1:

(1-φ), 2 wire, 15 km,  $d = 0.8 \text{ cm}$   $D = 40 \text{ cm}$ Find  $L_{\text{Total}}$  of line-

$$L_T = \left( 4 \times 10^{-7} \ln \frac{D}{r} \right) \times 15 \text{ km}$$

$$= \left( 4 \times 10^{-7} \ln \frac{40 \times 10^{-2}}{0.4 \times 10^{-2} \times 0.7788} \right) \times 15 \text{ km} = 29.13 \text{ mH}$$

Given:  $r_a = r_b = r_c = 0.2 \text{ cm}$  $r_d = r_e = 0.4 \text{ cm}$  Find  $L_x$ 

$$L_x = \frac{2 \times 10^{-7}}{3 \times 2} \ln \frac{\text{GMD}}{\text{GMR}}$$

$$\text{GMD} = \sqrt{(ad)(ae)(bd)(be)(cd)(ce)}$$

$$= \sqrt[3 \times 2]{6 \times 7.2 \times 7.2 \times 6 \times 10 \times 7.2} = 7.1567$$

$$\text{GMR}_x = \sqrt[3 \times 3]{(aa)(ab)(ac)(bb)(ba)(bc)(cc)(ca)(cb)}$$

$$= \sqrt[9]{(0.7788 \times 0.2 \times 10^{-2})^3 \times 4 \times 8 \times 4 \times 4 \times 8 \times 4} = 0.34$$

$$\therefore L_x = \frac{2 \times 10^{-7} \times \ln \frac{7.1567}{0.34}}{0.34} = 6.09 \times 10^{-1} \text{ H/m}$$



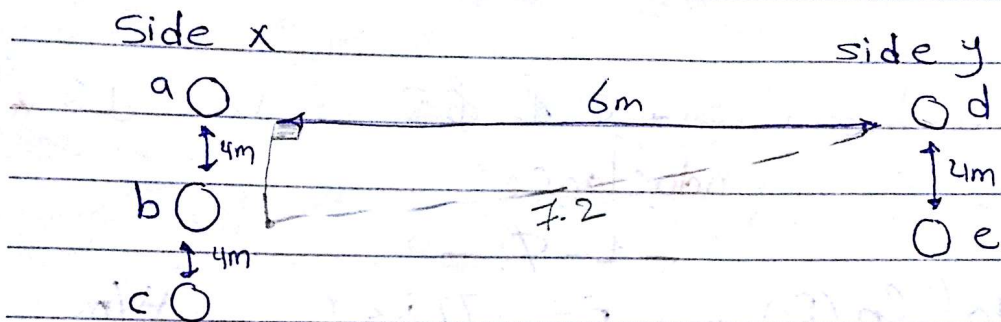
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$$\text{GMR}_x = \sqrt[3 \times 3]{(aa)(ab)(ac)(bb)(ba)(bc)(cc)(ca)(cb)}$$

$$= \sqrt[9]{(.7788 \times .2 \times 10^{-2})^3 \times 4 \times 8 \times 4 \times 4 \times 8 \times 4} = 0.34$$

$$\therefore L_x = 2 \times 10^{-7} \times \ln \frac{7.1567}{0.34} = 6.09 \times 10^{-1} \text{ H/m}$$



$$GMR_y = \sqrt{(-7788 \times 4 \times 10^{-2})^2 (4 \times 4)} = 112 \text{ m}$$

$$\therefore L_y = 2 \times 10^{-7} \ln \frac{7.1567}{1} = 8.31 \times 10^{-7} \text{ H/m}$$

$$\therefore L_T = 14.4 \times 10^{-7} \text{ H/m}^{1/2}$$

3-φ

- For equal spaced phases:

$$L_A = L_B = L_C = 2 \times 10^{-7} \ln \left( \frac{D}{r} \right) \text{ H/m Per Phase}$$

- For transposed phases that weren't equal spaces

$$L_a = L_b = L_c = 2 \times 10^{-7} \ln \frac{GMD}{r}$$

$$GMD = \sqrt[3]{D_{ab} D_{bc} D_{ca}}$$

sheet:

③ 3-φ, 50 Hz, D = 1.5 m, d = 1.5 cm

Find L/m per phase & X<sub>L</sub>

$$L = 2 \times 10^{-7} \ln \frac{1.5}{-7788 \times 75 \times 10^{-2}} = 11.097 \times 10^{-7} \text{ H/m Per Phase}$$

$$X_L = \omega L = 2\pi f L = 0.3486 \times 10^{-3} \Omega/\text{m per phase}$$

④ 3-φ, 50 Hz, d = 1.5 cm, D<sub>ab</sub> = 5 m, D<sub>bc</sub> = 4 m

D<sub>ca</sub> = 3 m Find L & X<sub>L</sub> if transposed

$$L_a = 2 \times 10^{-7} \ln \frac{GMD}{r}$$

$$\bar{r} = -7788 \times 75 \times 10^{-2} = 5.841 \times 10^{-3}$$

$$GMD = \sqrt[3]{5 \times 4 \times 3} = 3.914$$

$$L = 2 \times 10^{-7} \ln \frac{5.841 \times 10^{-3}}{3.914} = 1.49 \times 10^{-5} \text{ H/m Per Phase}$$

$$X_L = \omega L = 2\pi f L = 2\pi \times 50 \times 1.49 \times 10^{-5} = 0.4688 \Omega/\text{m per phase}$$



sec ②

PAGE

DATE

The circuit diagram is shown below. The input signal is a square wave with a period of 100 ns. The output signal is a square wave with a period of 100 ns. The output signal is inverted relative to the input signal. The output signal is also delayed relative to the input signal. The delay is approximately 10 ns. The output signal is also distorted relative to the input signal. The distortion is approximately 10%.

The circuit diagram is shown below. The input signal is a square wave with a period of 100 ns. The output signal is a square wave with a period of 100 ns. The output signal is inverted relative to the input signal. The output signal is also delayed relative to the input signal. The delay is approximately 10 ns. The output signal is also distorted relative to the input signal. The distortion is approximately 10%.

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The circuit diagram is shown below. The input signal is a square wave with a period of 100 ns. The output signal is a square wave with a period of 100 ns. The output signal is inverted relative to the input signal. The output signal is also delayed relative to the input signal. The delay is approximately 10 ns. The output signal is also distorted relative to the input signal. The distortion is approximately 10%.

The circuit diagram is shown below. The input signal is a square wave with a period of 100 ns. The output signal is a square wave with a period of 100 ns. The output signal is inverted relative to the input signal. The output signal is also delayed relative to the input signal. The delay is approximately 10 ns. The output signal is also distorted relative to the input signal. The distortion is approximately 10%.



4

Ayala

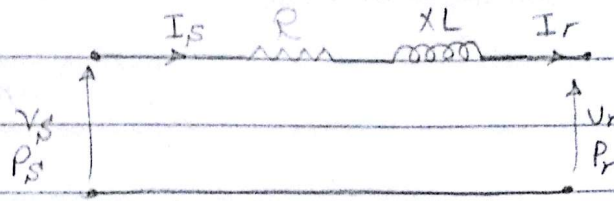
29/10/2016  
From Aya Anber

Sec ③

PAGE

DATE

short transmission line :



$$V_s = A V_r + B I_r$$

$$I_s = C V_r + D I_r$$

KVL at the Loop

$$\rightarrow V_s = V_r + I_r (R + jXL)$$

$$V_s = V_r + I_r Z \quad \rightarrow A=1, B=Z$$

$$\rightarrow I_s = I_r \quad \rightarrow C=0, D=1$$

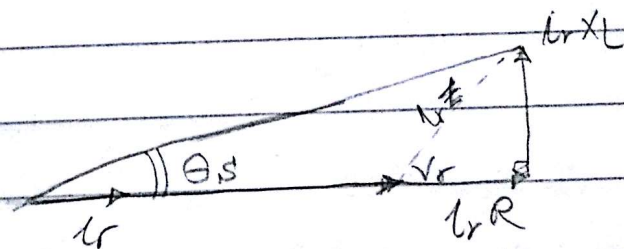
- : مسائل S.T.L يطلب

$$\bullet P_s = |V_s| |I_s| \cos(\theta_s - \theta_s), \quad \cos(\theta_s - \theta_s)$$

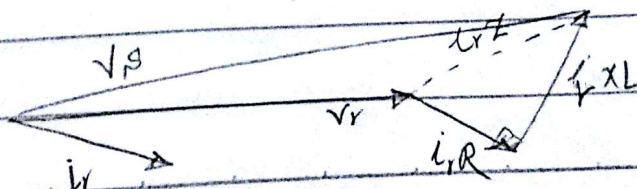
$$\bullet \eta = (P_r / P_s) \times 100$$

$$\bullet V_{reg} = \frac{V_{NL} - V_{FL}}{V_{FL}}$$

unity PF



Lag PF





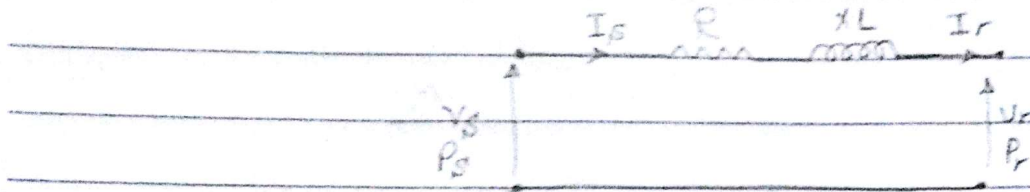
4

Ayala

29/10/2016  
From Asa Akbar

sec ③

short transmission line :



$$V_s = A V_r + B I_r$$

$$I_s = C V_r + D I_r$$

KVL at the Loop

$$\rightarrow V_s = V_r + I_r (R + jXL)$$

$$V_s = V_r + I_r Z \quad \rightsquigarrow \quad A=1, B=Z$$

$$\rightarrow I_s = I_r \quad \rightsquigarrow \quad C=0, D=1$$

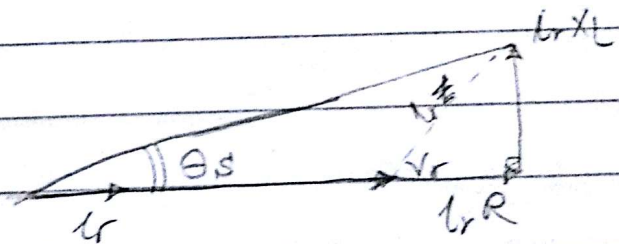
- : مسائل S.T.L يطلب

$$\bullet P_s = |V_s| |I_s| \cos \theta_s, \quad \cos \theta_s = \cos (\theta_s - \theta_r)$$

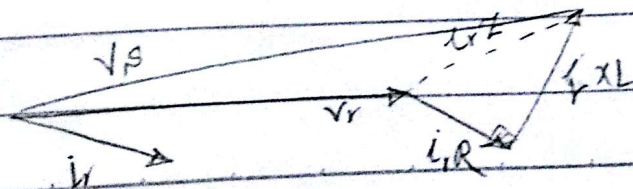
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unity PF

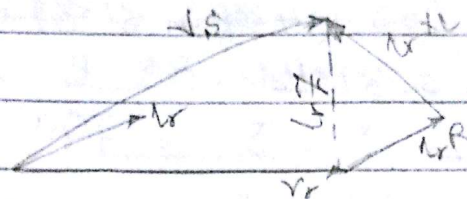


Lag PF





## Lead PF



نأخذ بالاعتبار أننا نشتغل على Phase 1 لأن يكونو على نفس الطور  
وكن بيك ونفهم في المبدأ :-

$$V_L \xrightarrow[\text{الخطى}]{V_{ph}} V_{ph} = \frac{V_L}{\sqrt{3}}$$

$$P_{3\phi} \rightarrow P_{\phi} = \frac{P_{3\phi}}{3}$$

أما بقيت ما بين خلاص حسابات تكون جايين على Phase 1 وهو  
مدلنا جهد line يبقى الجهد المحسوب نظريه  $\times \sqrt{3}$ .

## Sheet 3:

① (3- $\phi$ ) , 60 Hz , 0 H.TL

$$V_r (L-L) = 23 kV \quad Z/ph = 2.48 + j6.57 \Omega$$

$$P_r = 9 MW \quad P_{fr} = 0.85 \text{ Lag}$$

calculate :  $V_s (L-G)$  ,  $P_{fs}$

$I_{line}$  ,  $V_{reg} (line)$

A, B, C, D

Draw phasor digrame

$$① V_r = 23 kV \div \sqrt{3} = 13.279 kV$$

$$V_s = V_r + I_r Z$$

$$P_{rph} = \frac{9 \times 10^6}{3} = 3 MW$$

$$P_{fr} = 0.85 \text{ Lag}$$

$$I_r = \frac{P_{rph}}{V_{ph} \cdot P_{fr}} \quad \angle -\cos^{-1} P_{fr} = 265.78 / -31.78^\circ A$$



$$V_s = 13.279 \times \frac{265.78}{14802.7} \times (2.48 + j6.57)$$

$$\rightarrow P_{fs} = \cos(4.4 + 31.8)$$

$$= 0.81 \text{ Lag}$$

$$\textcircled{2} \eta = \frac{P_{out}}{P_{in}} \times 100$$

$$P_s = |V| |I_s| P_{fs}$$

$$\therefore \eta = \frac{3 \times 10^6}{14.8 \times 265.8 \times 0.81} \times 100 = 94.149\%$$

$$V_{reg} = \frac{V_{NL} - V_{FL}}{V_{FL}} = \frac{14.8 \times 10^3 - 13.27 \times 10^3}{13.27 \times 10^3} \times 100$$

$$= 11.3\%$$

في المسائل لازم اعمل comment على الازدحام.

- بالنسبة للكفاءة فهي جيدة. تأثير المقاومة صغير.  
- بالنسبة لـ  $V_{reg}$  فهو مرتفع جداً وذلك لان تأثير  $L$  مرتفع.

$\textcircled{3}$  For short T.O.L

$$A = D = 1$$

$$C = 0$$

$$B = Z = 7.022 / 69.3$$

$\textcircled{4}$  نراعي واننا نرسم لا phasor القيم والارقاس

هنا مش هرسم scale اوى بيها اراعي النسبة بين الاصول

في المسألة دي مثلاً عندي  $V_r = 13$  والـ  $V_s = 14$  يعني فرق بينهم بعض



$$V_p = 13.279K + 265.78 / -31.78 + (2.48 - 56.57)$$

$$14802.7 \quad 14.406 \quad V$$

$$\rightarrow Pfs = \cos(4.4 + 31.8)$$

$$= 0.81 \text{ Lag}$$

$$\textcircled{2} \eta = \frac{Pr \phi + 100}{P_{S \phi}}$$

$$P_s = |V| |I_s| Pfs$$

$$\therefore \eta = \frac{3 \times 10^6}{14.8K \times 265.8 \times 0.81} \times 100 = 94.143\%$$

$$V_{reg} = \frac{V_{NL} - V_{FL}}{V_{FL}} = \frac{14.8 \times 10^3 - 13.27 \times 10^3}{13.27 \times 10^3} \times 100$$

$$= 11.3\%$$

في المسائل لازم اعمل comment على الادوار.

- بالنسبة للكفاءة فهي جيدة: تأثير المقاومة صغير.  
- بالنسبة لـ  $V_{reg}$  فهو مرتفع جداً وذلك لان تأثير  $\textcircled{1}$  مرتفع.

$\textcircled{3}$  For short T.O.L

$$A = D = 1$$

$$C = 0$$

$$B = Z = 7.022 / 69.3$$

نراي واحنا بنرسم ال phasor القيم والارقاس  $\textcircled{4}$

بعض مش هيرسم scale اوى بيه اراي النسبة بين الاصول

في المسألة دي مثلاً عندى  $V_r = 13$  والـ  $V_L = 14$  يعني فرق بين مربعين



② 3- $\phi$ ,  $l = 40 \text{ km}$ ,  $R/\text{ph } 1 \text{ km} = 0.15 \Omega$   
 $L/\text{ph } 1 \text{ km} = 1.33 \text{ mH}$

Calculate:  $V_s$ ,  $P_s$ ,  $V_{\text{reg}}$ ,  $\eta$  (if)

3- $\phi$  Load  $\rightarrow S = 380 \text{ MVA}$

$\text{PF} = 0.8 \text{ Lag}$

$V_r = 220 \text{ kV}$

$$Z = 0.15 \times 40 + j10\pi \times 40 \times 1.33 \times 10^{-3}$$

$$= (6 + j16.7)$$

$$V_s = V_r + I_s Z$$

$$V_{r\phi} = \frac{V_r L}{\sqrt{3}} = \frac{220 \times}{\sqrt{3}} = 127 \text{ k}$$

$$I_r = \frac{S_d}{V_{r\phi}} \angle -\cos^{-1} \text{PF}$$

$$\therefore I_r = 997.3 \angle -36.86$$

$$V_s = 127 \text{ k} + (997.3 \angle -36.86 \times 6 + j16.7)$$

$$= 142.1 \angle 3.94 \text{ kV}$$

$$V_s(L) = V \times \sqrt{3} \quad \#$$

$$P_s = 3 |V_{s\phi}| |I_s| \text{PF}_s$$

$$\text{PF}_s = \cos(\hat{V}_{s\phi} - \hat{I}_s)$$

$$= \cos(3.94 + 36.87) = 0.76 \text{ Lag}$$

$$\therefore P_s = 321.5 \text{ MW} \quad \#$$



$$\eta = \frac{P_{rd}}{P_{s\phi}} = \frac{P_{r3\phi}}{P_{s3\phi}} \times 100$$

$$= \frac{S_{r3\phi} \times P_{fr}}{321.5 \times 10^6} \times 100 = 94.56\%$$

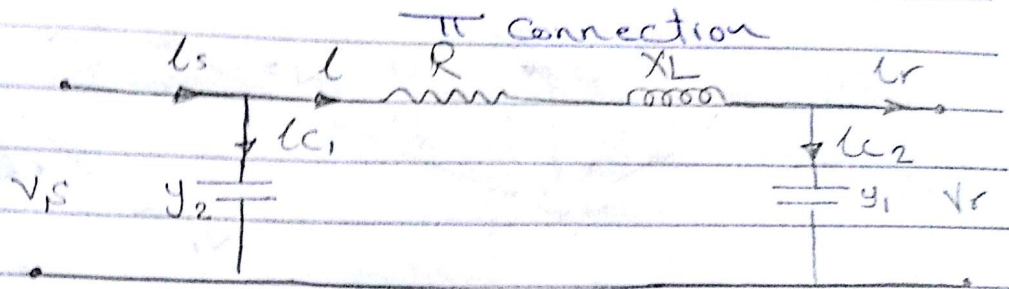
$$V_{reg} = \frac{V_{NL} - V_{FL}}{V_{FL}}$$

$$= \frac{V_{s\phi} - V_{r\phi}}{V_{r\phi}} \times 100 = 11.78\%$$



sec : 4

## Medium TL



$$Y = \frac{1}{X_C} = 2\pi fC$$

$$V_s = AV_r + R I_r$$

$$I_s = C V_r + D I_r$$

$$A = D = 1 + \frac{ZY}{2}$$

$$B = Z$$

$$C = Y \left( 1 + \frac{ZY}{4} \right)$$

المطلوب

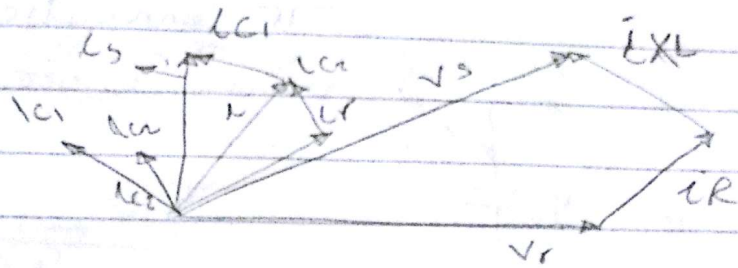
\*  $A, B, C, D$

\*  $V_s, I_s, P_{fs}$

$$* \eta = \frac{P_o}{P_{in}} \times 100 = \frac{P_r}{P_s} \times 100$$

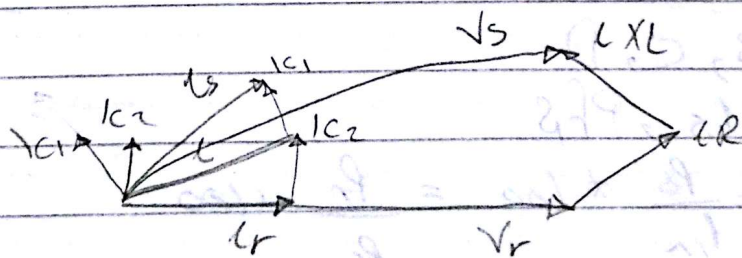
$$* V_{reg} = \frac{V_{nL} - V_{sc}}{V_{fc}} = \frac{\left| \frac{V_s}{A} \right| - |V_r|}{|V_r|}$$





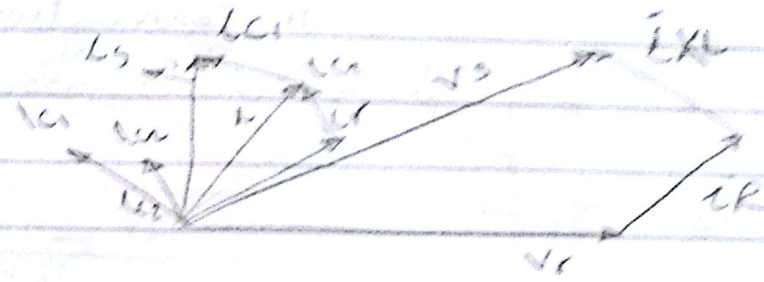
Lead phasor

Lag phasor



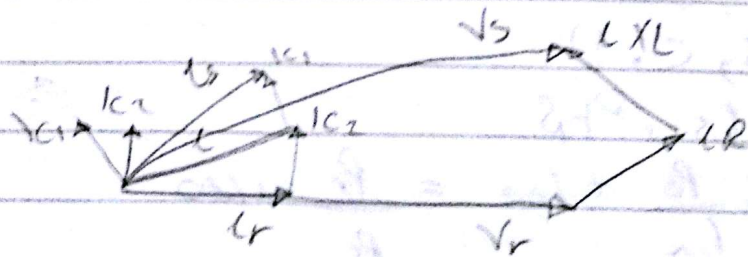
unity phasor





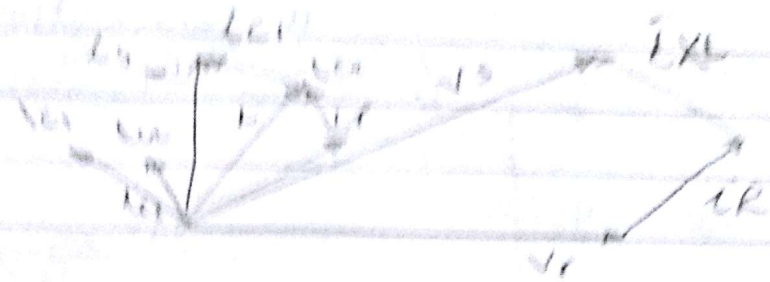
Lead phasor

Lag phasor



unity phasor





Lead phasor

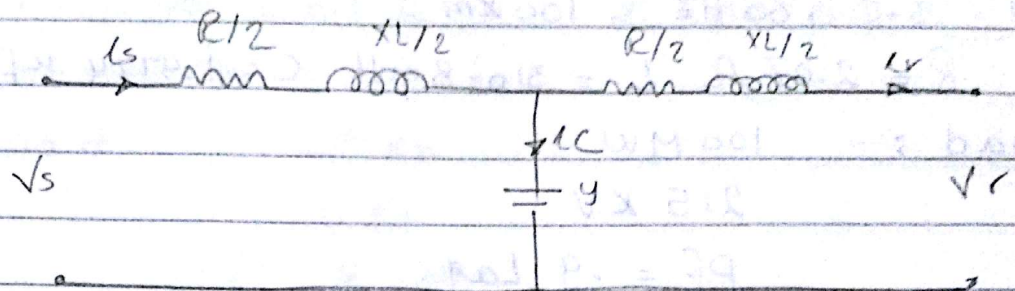
Lag phasor



unity phasor



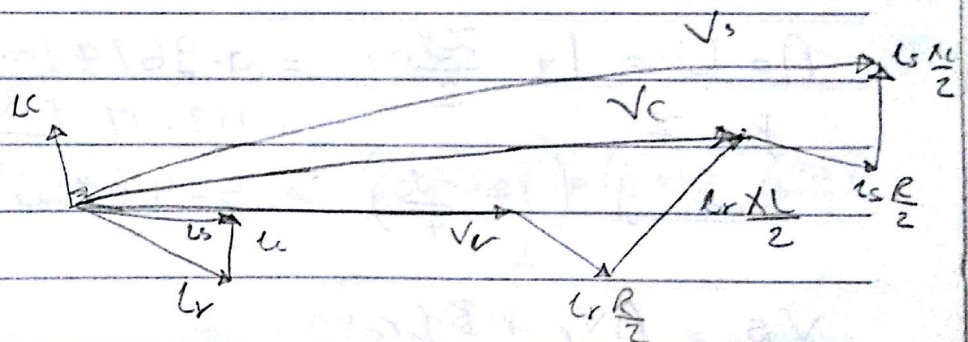
## T Connection



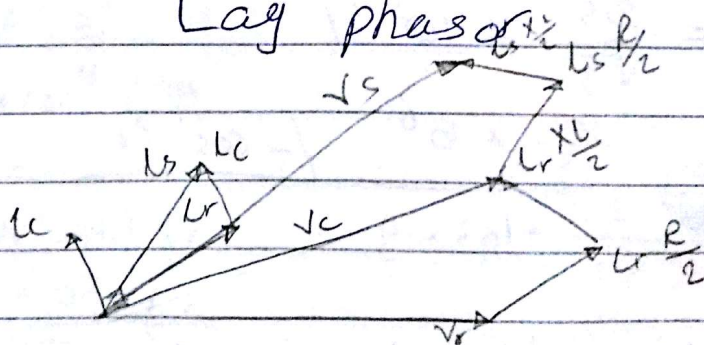
$$A = D = 1 + \frac{ZY}{2}$$

$$B = Z \left( 1 + \frac{ZY}{4} \right)$$

$$C = Y$$



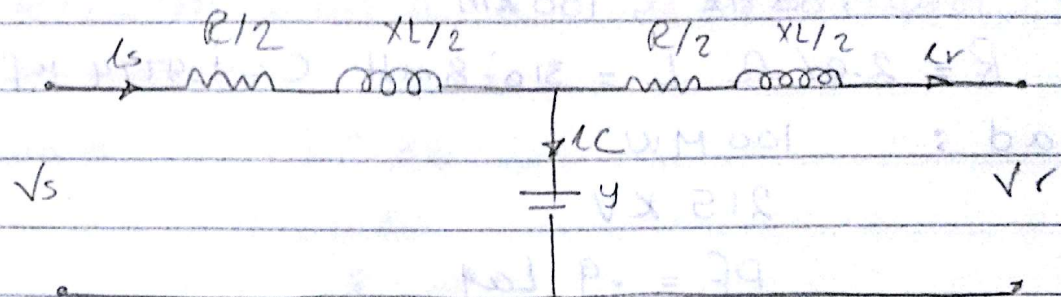
Lag phasor



Lead phasor



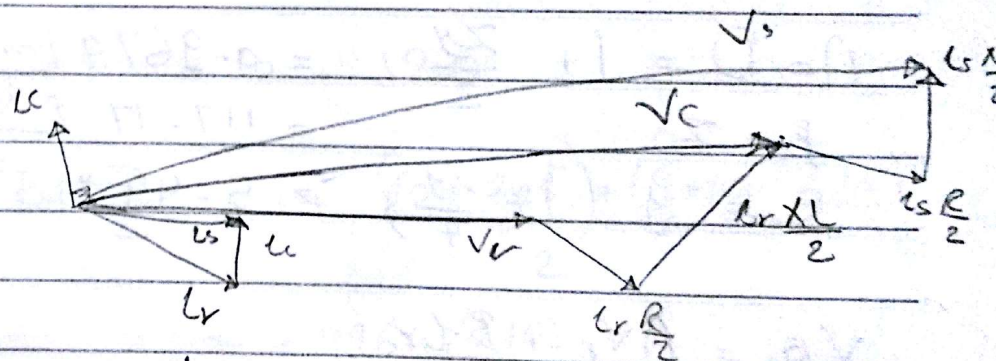
# T connection



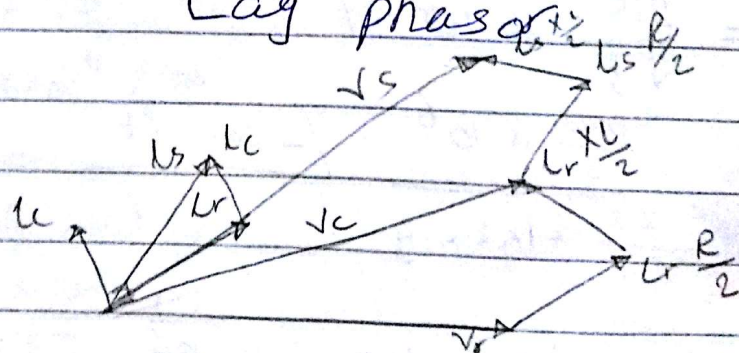
$$A = D = 1 + \frac{ZY}{2}$$

$$B = Z \left( 1 + \frac{ZY}{4} \right)$$

$$C = Y$$



Lag phasor



Lead phasor



sheet :

1) 3- $\phi$ , 60 Hz, 100 km

$$R = 2.07 \Omega \quad L = 310.8 \text{ mH} \quad C = 1.4174 \mu\text{F}$$

Load : 100 MW

215 kV

PF = .9 Lag

→ Requirde : ① A, B, C, D

② VS

~~π~~ π Connection

SOL

$$Z_{TL} = R + jX_L = 117.17 / 88.99^\circ \Omega$$

$$Y = 2\pi FC / 90 = 0.559 \times 10^{-3} / 90$$

$$A = D = 1 + \frac{ZY}{2} = 0.9674 / 0.034$$

$$B = Z = 117.17 / 88.99$$

$$C = Y \left( 1 + \frac{ZY}{4} \right) = 5.49 \times 10^{-4} / 90$$

$$V_S = AV_r + B I_r$$

$$V_r = \frac{215}{\sqrt{3}} \times 10^3 \text{ V}$$

$$I_r = \frac{\frac{100}{3} \times 10^6}{\frac{215}{\sqrt{3}} \times 10^3 \times .9} / -\cos^{-1} \text{PF} = 298.37 / -25.16^\circ$$

$$V_S = 139.42 / 12.96^\circ \text{ kV}$$

$$V_{S_L} = 241.5 \text{ kV}$$



sheet :

1) 3- $\phi$ , 60 Hz, 100 km

$$R = 2.07 \Omega \quad L = 310.8 \text{ mH} \quad C = 1.4774 \mu\text{F}$$

Load : 100 MW

215 kV

PF = .9 Lag

→ Requirde : ① A, B, C, D

② VS

⊗ W correction

sol

$$Z_{TL} = R + jX_L = 117.17 / 88.99^\circ \Omega$$

$$Y = 2\pi FC / 90 = 0.559 \times 10^{-3} / 90$$

$$A = D = 1 + \frac{ZY}{2} = 0.9674 / 0.034$$

$$B = Z = 117.17 / 88.99$$

$$C = Y \left( 1 + \frac{ZY}{4} \right) = 5.49 \times 10^{-4} / 90$$

$$V_S = AV_r + B I_r$$

$$V_r = \frac{215}{\sqrt{3}} \times 10^3 \text{ V}$$

$$I_r = \frac{\frac{100}{3} \times 10^6}{\frac{215}{\sqrt{3}} \times 10^3 \times 0.9} \angle -\cos^{-1} \text{PF} = 298.37 / -25.96^\circ$$

$$V_S \phi = 139.42 / 12.96^\circ \text{ kV}$$

$$V_{S_L} = 241.5 \text{ kV}$$



2) 3- $\phi$ ,  $f = 50$  Hz, 100 km

$$R/\text{km}/\text{ph} = 0.1 \Omega \quad X_L/\text{km}/\text{ph} = 0.2 \Omega$$

$$Y/\text{km}/\text{ph} = 0.04 \times 10^{-4} \text{ } \checkmark$$

$$\text{Load} \quad 10^4 \text{ kW}$$

$$66 \text{ kV}$$

$$.8 \text{ Lag}$$

$$R_{eq} \rightarrow \textcircled{1} I_s$$

$$\textcircled{2} V_s$$

$$\textcircled{3} \text{ } \checkmark$$

T connection

$$R_T = .1 \times 100 =$$

$$X_{LT} = .2 \times 100 =$$

$$Y_T = .04 \times 10^{-4} \times 100 = 4 \times 10^{-4} \angle 90^\circ$$

$$Z_{TL} = R + jX_L = 10 + j20$$

$$A = D = 1 + \frac{Z_T Y}{2} = 1 + \frac{(10 + j20) \times (4 \times 10^{-4} \angle 90^\circ)}{2}$$

$$= .996 \angle -11.5^\circ$$

$$B = 22.316 \angle 63.49^\circ$$

$$C = Y = 4 \times 10^{-4} \angle 90^\circ$$

$$I_s = C V_r + D I_r$$

$$V_r = \frac{66 \times 10^3}{\sqrt{3}} \angle 0^\circ$$

$$I_r = \frac{P/3}{V_r \cos \phi} \angle -\cos^{-1} \text{PF}$$

$$= 109.35 \angle -36.8^\circ$$





$$V_{S\phi} = A V_r + B I_r \rightarrow 40.151 \angle 1.67$$

$$I_S = C V_r + D I_r \rightarrow 100.54 \angle -29.78$$

$$V_{SL} = 69.54 \angle 1.67^\circ \text{ KV}$$

$$\eta = \frac{P_r}{P_{in}} \times 100 = \frac{10^7 / 3}{V_S I_S \text{ Pfs}}$$

$$\text{Pfs} = \cos(\hat{V}_{S\phi} - \hat{I}_S)$$

$$= \cos(1.67 - (-29.78)) = -85 \text{ lag}$$

3)  $l = 100 \text{ km}$  3- $\phi$  50 Hz

$$R / \text{km} / \phi = 0.1 \Omega$$

$$X_L / \text{km} / \phi = 0.5 \Omega$$

$$Y / \text{km} / \phi = 10 \times 10^{-6}$$

Load: 20 MW

0.9 Lag

66 KV,  $\pi$  Connection

Req: ① Pfs ② Reg ③  $\eta$

$$Z_{TL} = (0.1 + j0.5) \times 100 = 10 + j50 \Omega$$

$$Y = 10 \times 10^{-6} \times 10^2 = 10^{-4} \times 10 \Omega$$

$$A = D = 1 + \frac{ZY}{2} = 0.975 \angle 0.29$$

$$B = Z$$

$$= 50.99 \angle 78.69$$

$$C = \left(1 + \frac{ZY}{4}\right) Y = 0.988 \times 10^{-3}$$

$$\angle 90.15$$



$$V_s = 42.44 / 12.41 \text{ kV}$$

$$I_s = 176.5 / -14.48 \text{ A}$$

$$V_r = \frac{66 \text{ k}}{\sqrt{3}}$$

$$I_r = \frac{P/3}{V_r \text{ PF}} \quad \angle -\cos^{-1} \text{ PF}$$

$$V_r \text{ PF}$$

$$= 194.4 / -25.84 \text{ A}$$

$$\text{PF} = \cos(\hat{V}_s - \hat{I}_s)$$

$$= \cos(12.41 - (-14.48))$$

$$= -0.892 \text{ Lag}$$

$$\text{Reg} = \frac{\left| \frac{V_s}{A} \right| - V_r}{V_r} \times 100 = 14.24 \%$$

$$\eta = \frac{P_r}{P_s} = \frac{20 \times 10^6}{V_s I_s \text{ PF}_s} = 99.7\%$$

$$42.44 \times 176.5 \times -0.892$$



Sec: 5

Long T.L

$$A = D = \cosh \theta = 1 + \frac{ZY}{2}$$

$$B = Z \frac{\sinh \theta}{\theta} = Z \left(1 + \frac{ZY}{6}\right)$$

$$C = Y \frac{\sinh \theta}{\theta} = Y \left(1 + \frac{ZY}{6}\right)$$

$$\text{Where } \theta = \sqrt{ZY}$$

→ We use the eqns:

$$V_s = A V_r + B I_r$$

$$I_s = C V_r + D I_r$$

→ Regs:

$$\% \eta = \frac{P_s}{P_r} \times 100 = \frac{V_r \cdot I_r \cdot \text{Pfr}}{V_s \cdot I_s \cdot \text{Pfs}} \times 100$$

$$\% V_{\text{reg}} = \frac{V_{\text{NL}} - V_{\text{FL}}}{V_{\text{FL}}} = \frac{\left| \frac{V_s}{A} \right| - V_r}{V_r} \times 100$$

$V_{\text{NL}}$  :- voltage across  $I_r$  when  $I_r = 0$  (no load)  $\rightarrow$   $\left( \frac{V_s}{A} \right)$

→ Ideas: in no load case:

$$V_s = V_{\text{s FL}}$$

$$I_s = C \cdot \frac{V_s}{A}$$

$$I_{\text{ch}} = I_{\text{s nl}}$$



sheet(5)

(1)

$$Z = (R + jXL) \times l$$

$$Y = 2\pi fC \times l / 90$$

$$\rightarrow A = D = 0.9572 / 0.65$$

$$B = 110.597 / 75.76 \quad \Omega$$

$$C = 7.8667 \times 10^{-4} / 90.2 \quad \text{S}$$

(2)

3- $\phi$ , double circuit,  $f = 50 \text{ Hz}$ ,  $l = 244 \text{ km}$

$$R = 0.217 \quad \Omega / \text{km} / \text{ph} / \text{circuit}$$

$$X_L = 0.302 \quad \Omega / \text{km} \sim \sim$$

$$Y = 3.96 \times 10^{-6} \quad \text{S} / \text{km} \sim \sim$$

$$\text{Load :- } P_r = 450 \text{ MW}$$

$$V_r = 500 \text{ KV}$$

$$P_{fr} = 0.85 \text{ Lag}$$

Req<sup>n</sup>- A, B, C, D &  $V_s$

sol: For being double circuit  $\therefore$

$$R_T = \frac{R_{cir}}{2}$$

$$X_{LT} = \frac{X_{Lcir}}{2}, \quad Y_T = Y_{cir} \times 2$$

$$\rightarrow I_r = \frac{P_r / 3}{\frac{V_r}{\sqrt{3}} \times P_{fr}} \quad / -\cos^{-1} P_f$$

$$\rightarrow V_s = \underbrace{A V_r}_{\substack{\downarrow \\ 500 \text{ K}}} + \underbrace{B I_r}_{\substack{\downarrow \\ \sqrt{3}}}$$



sheet(5)

(1)

$$Z = (R + jXL) \times l$$

$$Y = 2\pi fC \times l / 90$$

$$\Rightarrow A = D = 0.9572 / 0.65$$

$$B = 110.597 / 75.76$$

$$C = 7.8667 \times 10^{-4} / 90.2$$

(2)

3- $\phi$ , double circuit,  $f = 50 \text{ Hz}$ ,  $l = 244 \text{ km}$

$$R = 0.217 \Omega / \text{km} / \text{ph} / \text{circuit}$$

$$X_L = 0.302 \Omega / \text{km} \sim \sim$$

$$Y = 3.96 \times 10^{-6} \text{ S} / \text{km} \sim \sim$$

Load :-  $P_r = 450 \text{ MW}$

$$V_r = 500 \text{ kV}$$

$$\text{Pfr} = 0.85 \text{ Lag}$$

Reqs- A, B, C, D &  $V_s$

Sol: For being double circuit :-

$$R_T = \frac{R_{\text{cir}}}{2}$$

$$X_{LT} = \frac{X_{L\text{cir}}}{2}, \quad Y_T = Y_{\text{cir}} \times 2$$

$$\rightarrow I_r = \frac{P_r / 3}{\frac{V_r}{\sqrt{3}} \times \text{Pfr}} \quad 1 - \cos^2 \phi$$

$$\rightarrow V_s = A V_r + B I_r$$

$\downarrow$   
 $\frac{500 \text{ kV}}{\sqrt{3}}$



$$V_{s\phi} = 292.117 / 3.741 \text{ KV}$$

$$V_{SL} = 505.921 / 3.741 \text{ KV}$$

(3)

$$3-\phi, f = 50 \text{ Hz}, l = 300 \text{ km}$$

$$Z / \text{Ph} / \text{km} = 0.0145 + j0.17 \Omega$$

$$Y / \text{Ph} / \text{km} = 4.6 \times 10^{-6} \text{ S}$$

$$\text{Load} : P_r = 150 \text{ MW}$$

$$V_r = 220 \text{ KV}$$

$$P_{fr} = 0.9 \text{ Lag}$$

$$\text{Req: } \textcircled{1} A, B, C, D$$

$$\textcircled{2} V_s, I_s, P_{fs}$$

$$\textcircled{3} \gamma, V_{reg}$$

$$\textcircled{4} V_s, I_s, P_f, P_{fs}, I_{ch} \rightarrow \text{no Log}$$

Sol:

$$Z_{TL} = (0.0145 + j0.17) \times 300 = 51.185 / 85.125^\circ \Omega / \text{Ph}$$

$$Y_{TL} = 4.6 \times 10^{-6} \times 300 / 90 = 13.8 \times 10^{-4} / 90^\circ \text{ S} / \text{Ph}$$

$$\rightarrow A = D = 1 + \frac{Z_Y}{2} = 0.965 / 0.18^\circ$$

$$B = Z \left( 1 + \frac{Z_Y}{8} \right) = 50.586 / 85.183^\circ \Omega$$

$$C = Y \left( 1 + \frac{Z_Y}{8} \right) = 1.364 \times 10^{-4} / 90.058^\circ \text{ S}$$

$$\boxed{2} V_{s\phi} = A V_r + I_r B$$

$$V_{r\phi} = \frac{220 \text{ KV}}{\sqrt{3}}$$

$$I_r = \frac{P_r / 3}{\frac{V_r}{\sqrt{3}} \times P_{fr}} \angle -\cos^{-1} P_f = 437.387 / -25.84^\circ \text{ A}$$

$$V_{s\phi} = 135.254 / 8.255 \text{ KV}$$

$$V_{SL} = \sqrt{3} V_{s\phi} = 234.267 / 8.255 \text{ KV}$$



$$V_{s\phi} = 292.117 / 3.741 \text{ kV}$$

$$V_{sL} = 505.921 / 3.741 \text{ kV}$$

(3)

$$3-\phi, f = 50 \text{ Hz}, l = 300 \text{ km}$$

$$Z/\text{Ph}/\text{km} = 0.0145 + j0.17 \Omega$$

$$Y/\text{Ph}/\text{km} = 4.6 \times 10^{-6} \text{ S}$$

$$\text{Load} : P_r = 150 \text{ MW}$$

$$V_r = 220 \text{ kV}$$

$$P_{fr} = 0.9 \text{ Lag}$$

$$\text{Req: } \textcircled{1} A, B, C, D$$

$$\textcircled{2} V_s, I_s, P_{fs}$$

$$\textcircled{3} \gamma, V_{rag}$$

$$\textcircled{4} V_s, I_s, P_r, P_{fs}, I_{ch} \rightarrow \text{no Log}$$

Sol:

$$Z_{TL} = (0.0145 + j0.17) \times 300 = 51.185 / 85.125^\circ \Omega/\text{Ph}$$

$$Y_{TL} = 4.6 \times 10^{-6} \times 300 / 90 = 13.8 \times 10^{-4} / 90^\circ \text{ S/Ph}$$

$$\rightarrow A = D = 1 + \frac{ZY}{2} = 0.965 / 0.18^\circ$$

$$B = Z \left( 1 + \frac{ZY}{2} \right) = 50.586 / 85.183^\circ \Omega$$

$$C = Y \left( 1 + \frac{ZY}{2} \right) = 1.364 \times 10^{-4} / 90.058^\circ \text{ S}$$

$$\boxed{2} V_{s\phi} = AV_r + I_r B$$

$$V_{r\phi} = \frac{220 \text{ kV}}{\sqrt{3}}$$

$$I_r = \frac{P_r/3}{\frac{V_r}{\sqrt{3}} \times P_{fr}} \angle -\cos^{-1} P_{fr} = 437.387 / -25.84^\circ \text{ A}$$

$$V_{s\phi} = 135.254 / 8.255^\circ \text{ kV}$$

$$V_{sL} = \sqrt{3} V_{s\phi} = 234.267 / 8.255^\circ \text{ kV}$$



$$I_s = C V_r + D I_r = 380.397 / -1.434^\circ \text{ A}$$

$$P_{fs} = \cos(\hat{V}_s - \hat{I}_s) = \cos(8.255 - (-1.434)) = 0.9857 \text{ lag}$$

$$\boxed{3} \quad \eta = \frac{P_r}{P_s} \times 100 = 98.59\%$$

$$V_{reg} = \frac{V_{nl} - V_{fl}}{V_{fl}} = \frac{(V_s/A) - V_{r\phi}}{V_{r\phi}} = 10.347\%$$

→ note. The valid regulation is about (5%) \*\*\*

$\boxed{4}$  at no Load Condition:  $\Rightarrow I_r = 0$

$$\rightarrow V_{SL} = V_{SL, nL}$$

في الحالة دي بيكون ال Load طبقاً مش موجود  $\therefore$  مقيش  $I_s$   
يتار مسـوب للـ Load والـتيار المـستـحب كـله من الـ supply هو  
الـتيار الـذي فـي الـكـنـفـاتـ.

$$I_s = C * (V_s/A) \text{ من معادله } = 234.267 / 8.257^\circ$$

$$\rightarrow P_{fs} = \cos(\hat{V}_{s, nL} - \hat{I}_{s, nL}) = 191.177 / 98.133^\circ$$

$$\rightarrow P_s = 3 V_{s\phi, nL} \cdot I_{s, nL}, P_{fs} = 0.00213 \text{ Lead}$$

$$\rightarrow I_{ch} = I_s = 191.177 / 98.133^\circ \text{ زاوية التيار اكبر من زاوية الجهد}$$

## Insulators

Assume: we have 3 insulator

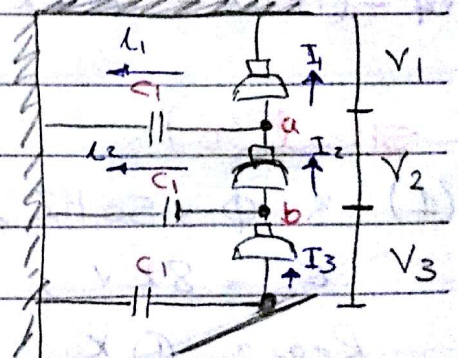
$$kcl \text{ at } a, k = \frac{C_1}{C}$$

$$I_2 = I_1 + I_1$$

$$wC V_2 = wC V_1 + wC_1 V_1$$

$$V_2 = V_1(1+k)$$

$$kcl \text{ at } b$$





$$I_3 = I_2 + I_2$$

$$WC V_3 = WC V_2 + WC_1 (V_2 + V_1)$$

$$V_3 = V_2 + K(V_2 + V_1)$$

$$= (1+K) V_2 + K V_1$$

→ substitute with  $V_2$

$$V_3 = (1+K)^2 V_1 + K V_1 = (1+3K+K^2) V_1$$

$$\rightarrow V_1 + V_2 + V_3 = V_\phi$$

$$\eta_{\text{string}} = \frac{V}{n \times V_3}$$

Assume: We have 4 units

KCL at a

$$V_2 = V_1 (1+K)$$

KCL at b

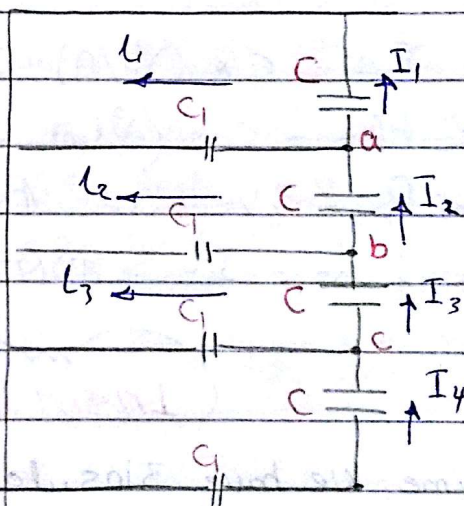
$$V_3 = V_1 (1+3K+K^2)$$

KCL at c

$$WC V_4 = WC V_3 + WC_1 (V_1 + V_2 + V_3) K$$

$$V_4 = V_3 + K(V_1 + V_2 + V_3)$$

$$V_4 = (1+6K+5K^2+K^3) V_1$$



sheet (6)

(1) 3- $\phi$ , 50 Hz, 3 insulator

$$E_1 = 8 \text{ kV}, E_2 = 11 \text{ kV}$$

Req: ① K ② V.L.L

③  $\eta_{\text{string}}$



Solution:

$$K = \frac{C_1}{C_2}, \quad E_2 = (1+K) E_1$$

$$11 = (1+K)8, \quad K = \frac{11}{8} - 1 = 0.375$$

$$\boxed{2} \quad V_{L-L} = \sqrt{3} V_{\phi}, \quad V_{\phi} = V_1 + V_2 + V_3$$

$$V_3 = (1 + 3K + K^2) V_1 = (1 + 3K + K^2) \times 8 = 18.125 \text{ kV}$$

$$\therefore V_{L-L} = 64 - 3KV$$

$$\boxed{3} \quad \eta = \frac{V_1 + V_2 + V_3}{n \times V_3} = \frac{8 + 11 + 18.125}{3 \times 18.125}$$

التي هي نسبة الجهد إلى الجهد

Long arms ①

Long spans ②

using guard ring ③



Sec : 6

For (3) insulator

$$K = \frac{C_1}{C}$$

$$V_2 = (1 + K) V_1$$

$$V_3 = (1 + 3K + K^2) V_1$$

$$V_{ph} = V_1 + V_2 + V_3$$

$$\eta_0 = \frac{V_{ph}}{n \times V_3}$$

For (4) insulator

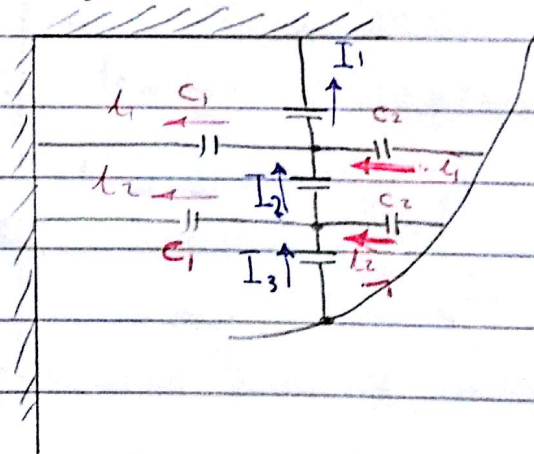
$$V_4 = (1 + 6K + 5K^2 + K^3) V_1$$

$$V_{ph} = V_1 + V_2 + V_3 + V_4$$

$$\eta_0 = \frac{V_{ph}}{n \times V_4}$$

"Guard ring"

At point A xcl



At point B xcl



sheet 6 - 2)

3- $\phi$ , 50 Hz, 3 insulator

self capacitance = C

shunt capacitance = 0.2 C

guard ring capacitance = 0.1 C

→ find  $\frac{E_1}{V_{ph}}$ ,  $\frac{E_2}{V_{ph}}$ ,  $\frac{E_3}{V_{ph}}$

$$C_2 (V_3 + V_2) + C V_2 = C V_1 + C_1 V_1$$

$$V_3 (C + C_2) = V_2 (C + C_1) + V_1 C_1$$

$$C_2 V_3 + V_2 (C_2 + C) - V_1 (C + C_1) = 0 \quad (1)$$

$$V_3 (C + C_2) - V_2 (C + C_1) - V_1 C_1 = 0 \quad (2)$$

$$0.1 C V_3 + V_3 (-1 C + C) - V_1 (C + 2 C) = 0$$

$$-1 C V_3 + 1.1 C V_2 - 1.2 C V_1 = 0$$

$$-1 V_3 + 1.1 V_2 - 1.2 V_1 = 0 \rightarrow (1)$$

$$V_3 (C + 0.1 C) - V_2 (C + 0.2 C) - V_1 \cdot 0.2 C = 0$$

$$1.1 V_3 - 1.2 V_2 - 0.2 V_1 = 0 \rightarrow (2)$$

$$V_{ph} = V_1 + V_2 + V_3$$

From (1)  $0.1 + 1.1 \frac{V_2}{V_3} - 1.2 \frac{V_1}{V_3} = 0$

Let  $\frac{V_2}{V_3} = y$  &  $\frac{V_1}{V_3} = x$

From (2)  $1.1 - 1.2 \frac{V_2}{V_3} - 0.2 \frac{V_1}{V_3} = 0$

$$0.1 + 1.1 y - 1.2 x = 0$$

$$1.1 - 1.2 y - 0.2 x = 0$$

$$\therefore y = 0.783$$

$$x = 0.801$$



sheet 6 - 2)

3- $\phi$  , 50 Hz , 3 insulator

self capacitance = C

shunt capacitance = 0.2 C

guard ring capacitance = 0.1 C

→ find  $\frac{E_1}{V_{ph}}$  ,  $\frac{E_2}{V_{ph}}$  ,  $\frac{E_3}{V_{ph}}$

$$C_2 (V_3 + V_2) + C V_2 = C V_1 + C_1 V_1$$

$$V_3 (C + C_2) = V_2 (C + C_1) + V_1 C_1$$

$$C_2 V_3 + V_2 (C_2 + C) - V_1 (C + C_1) = 0 \quad (1)$$

$$V_3 (C + C_2) - V_2 (C + C_1) - V_1 C_1 = 0 \quad (2)$$

$$0.1 C V_3 + V_3 (-1 C + C) - V_1 (C + 2 C) = 0$$

$$-1 C V_3 + 1.1 C V_2 - 1.2 C V_1 = 0$$

$$-1 V_3 + 1.1 V_2 - 1.2 V_1 = 0 \rightarrow (1)$$

$$V_3 (C + 0.1 C) - V_2 (C + 0.2 C) - V_1 \cdot 0.2 C = 0$$

$$1.1 V_3 - 1.2 V_2 - 0.2 V_1 = 0 \rightarrow (2)$$

$$V_{ph} = V_1 + V_2 + V_3$$

From (1)  $0.1 + 1.1 \frac{V_2}{V_3} - 1.2 \frac{V_1}{V_3} = 0$

Let  $\frac{V_2}{V_3} = y$  &  $\frac{V_1}{V_3} = x$

From (2)  $1.1 - 1.2 \frac{V_2}{V_3} - 0.2 \frac{V_1}{V_3} = 0$

$$0.1 + 1.1 y - 1.2 x = 0$$

$$1.1 - 1.2 y - 0.2 x = 0$$

$$\therefore y = 0.183$$

$$x = 0.801$$



sheet 6 - 2)

3- $\phi$ , 50 Hz, 3 insulator

self capacitance = C

shunt capacitance = 0.2C

guard ring capacitance = 0.1C

→ find  $\frac{E_1}{V_{ph}}$ ,  $\frac{E_2}{V_{ph}}$ ,  $\frac{E_3}{V_{ph}}$

$$C_2 (V_3 + V_2) + C U_2 = C V_1 + C_1 V_1$$

$$V_3 (C + C_2) = V_2 (C + C_1) + V_1 C_1$$

$$C_2 V_3 + V_2 (C_2 + C) - V_1 (C + C_1) = 0 \quad (1)$$

$$V_3 (C + C_2) - V_2 (C + C_1) - V_1 C_1 = 0 \quad (2)$$

$$0.1C V_3 + V_3 (-1C + C) - V_1 (C + 0.2C) = 0$$

$$-1C V_3 + 1.1C V_2 - 1.2C V_1 = 0$$

$$-1 V_3 + 1.1 V_2 - 1.2 V_1 = 0 \rightarrow (1)$$

$$V_3 (C + 0.1C) - V_2 (C + 0.2C) - V_1 \cdot 0.2C = 0$$

$$1.1 V_3 - 1.2 V_2 - 0.2 V_1 = 0 \rightarrow (2)$$

$$\rightarrow V_{ph} = V_1 + V_2 + V_3$$

From (1)  $0.1 + 1.1 \frac{V_2}{V_3} - 1.2 \frac{V_1}{V_3} = 0$

Let  $\frac{V_2}{V_3} = y$  &  $\frac{V_1}{V_3} = x$

From (2)  $1.1 - 1.2 \frac{V_2}{V_3} - 0.2 \frac{V_1}{V_3} = 0$

$$0.1 + 1.1y - 1.2x = 0$$

$$1.1 - 1.2y - 0.2x = 0$$

$$\therefore y = 0.783$$

$$x = 0.801$$



$$\therefore \frac{V_2}{V_3} = 0.783 \quad (1)$$

$$\frac{V_1}{V_3} = 0.801 \quad (2)$$

$$\therefore V_{ph} = V_1 + V_2 + V_3$$

$$\therefore V_{ph} = 0.801 V_3 + 0.783 V_3 + V_3$$

$$\therefore \frac{V_3}{V_{ph}} = 38.7\%$$

$$\frac{(1)}{(2)} = \frac{V_2}{V_1} = \frac{0.783}{0.801}$$

$$\frac{V_2}{V_{ph}} = 30.3\%$$

$$\frac{V_1}{V_{ph}} = 31\%$$

sheet 6 - 3) report

4) 3- $\phi$ , 50 Hz, 4 insulator

self capacitance  $\rightarrow C$

shunt capacitance  $\rightarrow C/16$

$$V_4 = 35 \text{ kV}$$

$\rightarrow$  Find \*V on each insulator

\*V.L.L

$$\therefore V_2 = V_1 (1 + K)$$

$$V_3 = V_1 (1 + 3K + K^2)$$

$$V_4 = V_1 (1 + 6K + 5K^2 + K^3)$$

$$K = \frac{\text{shunt } C}{\text{self } C} = \frac{C/16}{C} = \frac{1}{16}$$

$$X \text{ بالقوس لقيم } \rightarrow V_1 = \frac{V_4}{1 + 6K + 5K^2 + K^3} = 29.09 \text{ kV}$$

$$\therefore V_2 = 26.66 \text{ kV}$$

$$V_3 = 29.89 \text{ kV}$$



$$\therefore \frac{V_2}{V_3} = 0.783 \quad (1)$$

$$\frac{V_1}{V_3} = 0.801 \quad (2)$$

$$\therefore V_{ph} = V_1 + V_2 + V_3$$

$$\therefore V_{ph} = 0.801 V_3 + 0.783 V_3 + V_3$$

$$\therefore \frac{V_3}{V_{ph}} = 38.7\%$$

$$\therefore \frac{(1)}{(2)} \div \frac{V_2}{V_1} = \frac{0.783}{0.801}$$

$$\frac{V_2}{V_{ph}} = 30.3\%$$

$$\frac{V_1}{V_{ph}} = 31\%$$

sheet 6 - 3) report

\* \*

4) 3- $\phi$ , 50 Hz, 4 insulator

self capacitance  $\rightarrow C$

shunt capacitance  $\rightarrow C/16$

$$V_4 = 35 \text{ kV}$$

$\rightarrow$  Find \*V on each insulator

\*V.L.L

$$\therefore V_2 = V_1 (1 + K)$$

$$V_3 = V_1 (1 + 3K + K^2)$$

$$V_4 = V_1 (1 + 6K + 5K^2 + K^3)$$

$$K = \frac{\text{shunt } c}{\text{self } c} = \frac{C/16}{C} = \frac{1}{16}$$

$$K \text{ بالقوى لقيم} \rightarrow V_1 = \frac{V_4}{1 + 6K + 5K^2 + K^3} = 29.09 \text{ kV}$$

$$\therefore V_2 = 26.66 \text{ kV}$$

$$V_3 = 29.89 \text{ kV}$$



$$V_{LL} = \sqrt{3} V_{ph}$$

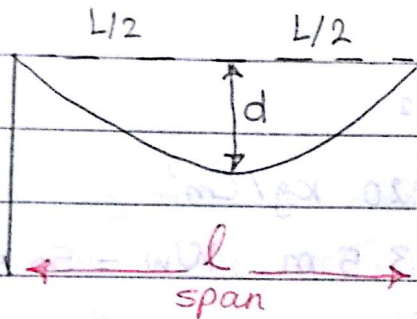
$$V_{LL} = \sqrt{3} (V_1 + V_2 + V_3 + V_4)$$

$$= 202.03 \text{ kV}$$

5) report \*\*

## Sag Calculation "

The support at the same level



span  $\rightarrow L$  (m)

sag  $\rightarrow d$  (m)

$W_c \rightarrow \text{kg/m}$

$T \rightarrow \text{kg}$

$W_w \rightarrow \text{kg/m}$

$W_i \rightarrow \text{kg/m}$

$a \rightarrow \text{cross area}$

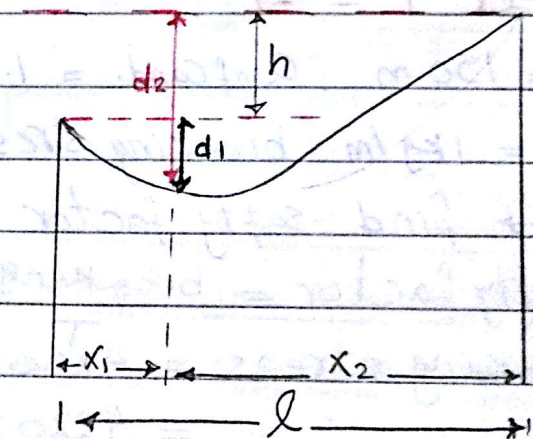
$$d = \frac{W_e L^2}{8T}$$

$$W_e = \sqrt{W_w^2 + (W_c + W_i)^2}$$

$$l_c = l \left( 1 + \frac{W_e^2 l^2}{24 T^2} \right)$$

$$\text{safety factor} = \frac{\text{breaking stress}}{T}$$

The support in different level



$$d_1 = \frac{W_e x_1^2}{2T}$$

$$d_2 = \frac{W_e x_2^2}{2T}$$

$$x_1 = \frac{L}{2} - \frac{T \cdot h}{W_e L}$$

$$x_2 = L - x_1$$

$$= \frac{L}{2} + \frac{T \cdot h}{W_e L}$$



$$V_{LL} = \sqrt{3} V_{ph}$$

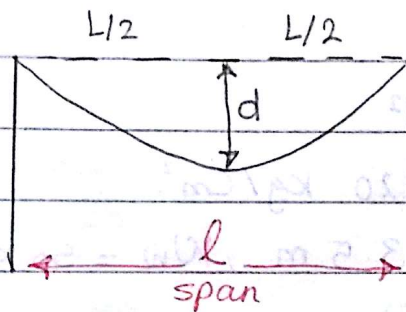
$$V_{LL} = \sqrt{3} (V_1 + V_2 + V_3 + V_4)$$

$$= 202.03 \text{ kV}$$

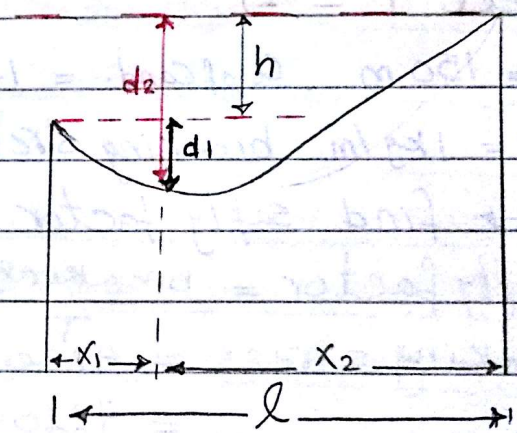
5) report \*\*

## "Sag Calculation"

The support at the same level



The support in different level



span  $\rightarrow L$  (m)

sag  $\rightarrow d$  (m)

$W_c \rightarrow \text{kg/m}$

$T \rightarrow \text{kg}$

$W_w \rightarrow \text{kg/m}$

$W_i \rightarrow \text{kg/m}$

$a \rightarrow \text{cross area}$

$$d = \frac{W_e L^2}{8T}$$

$$W_e = \sqrt{W_w^2 + (W_c + W_i)^2}$$

$$l_c = l \left( 1 + \frac{W_e^2 l^2}{24 T^2} \right)$$

$$\text{safety factor} = \frac{\text{breaking stress}}{T}$$

$$d_1 = \frac{W_e x_1^2}{2T}$$

$$d_2 = \frac{W_e x_2^2}{2T}$$

$$x_1 = \frac{L}{2} - \frac{T \cdot h}{W_e L}$$

$$x_2 = L - x_1$$

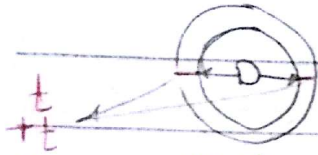
$$= \frac{L}{2} + \frac{T \cdot h}{W_e L}$$



\*\*\* مسائل sag مهمه جداً في الامتحان  
والدكتور حيا ينجي فيها

PAGE  
DATE

$$W_i = \rho \times \text{Area} \rightarrow \text{kg/m}$$



$$\text{Area} = \frac{\pi (D+2t)^2}{4} - \frac{\pi D^2}{4}$$

$$a \rightarrow \text{No ice} = \frac{\pi D^2}{4}$$

$$a \rightarrow \text{ice} = \frac{\pi (D+2t)^2}{4} - \frac{\pi D^2}{4}$$

Sheet 7 - 1)

$$L = 150 \text{ m} \quad a \text{ of Cond.} = 1.25 \text{ cm}^2$$

$$W_c = 1 \text{ kg/m} \quad \text{breaking stress} = 4220 \text{ kg/cm}^2$$

→ find safety factor if  $d = 3.5 \text{ m}$ ,  $W_w = 50 \text{ kg/m}^2$

safety factor = breaking stress

$$\begin{aligned} \text{breaking stress} &= 4220 (\text{kg/cm}^2) \times a \\ &= 4220 \times 1.25 = \text{kg} \end{aligned}$$

$$d = \frac{W_e l^2}{8T}$$

$$T = \frac{W_e l^2}{8d} \quad \begin{matrix} 150 \text{ m} \\ 3.5 \text{ m} \end{matrix}$$



$$W_e = \sqrt{W_c^2 + W_w^2} = \sqrt{1^2 + (50 \text{ kg/m}^2 \times D)}$$

$$D = \sqrt{4a/\pi} = 1.26 \text{ cm}$$

$$\therefore W_e = 1.182 \text{ kg/m}$$

$$T = 949.8 \text{ kg}$$

$$\therefore \text{Safety factor} = 5.55$$



sheet 7-2)

$$a = 2.2 \text{ cm}^2$$

$$W_c = 1.4 \text{ kg/m}$$

$$\text{ultimate stress} = 8000 \text{ kg/cm}^2$$

$$W_w = 40 \text{ kg/m}^2 \quad L = 300 \text{ m} \quad S_f = 3$$

→ find Vertical sag

$$S_f = \frac{\text{ultimate stress}}{T}$$

$$\therefore T = \frac{8000 \times 2.2}{3} = 5866.67 \text{ kg}$$

$$d = \frac{W_e l^2}{8T}, \quad W_e = \sqrt{W_c^2 + W_w^2}$$

$$W_w^2 = 40 \times D = 40 \times \sqrt{(4a/\pi) \times 10^2} =$$

$$\therefore W_e = 1.552 \text{ kg/m}$$

$$d = 2.976 \text{ m}$$

Vertical sag → means the sag resulting from the weight

$$W_e \longrightarrow d = 2.976$$

$$W_c \longrightarrow \bar{d} (?)$$

$$L \longrightarrow = 2.685 \text{ m}$$

If there is ice

$$W_e \longrightarrow d$$

$$W_c + W_i \longrightarrow \bar{d}$$



①

sec: 7

sheet 7 - 3 )

$$L = 200 \text{ m} \quad h = 10 \text{ m}$$

$$D = 2 \text{ cm} \quad w_c = 2.3 \text{ kg/m}$$

$$w_w = 57.5 \text{ kg/m}^2$$

$$S_f = 4, T_u = 4220 \text{ kg/m}^2$$

→ Find sag at the Lower support

$$** \quad d = w_e X_1^2$$

$$w_e = \sqrt{w_c^2 + w_w^2} \quad 2T \quad \sqrt{(2.3)^2 + (57.5 \times 2 \times 10^{-3})^2} =$$

$$X_1 = \frac{L_2}{2} - \frac{T \cdot h}{L \cdot w_e} = \frac{200}{2} - \frac{T \cdot 10}{200 \times 2.57} = 35.52 \text{ m}$$

$$S_f = \text{breaking stress} \rightarrow 4 = 4220 \times a^{\left(\frac{\pi D^2}{4}\right)}$$

$$T \therefore T = 3314.4 \text{ kg}$$

$$\therefore d = 0.49 \text{ m}$$

4 - Not in sheet)

$$L = 250 \text{ m}$$

$$w_c = 0.87 \text{ kg/m}$$

$$T_u = 8100 \text{ kg}$$

$$w_w = 38 \text{ kg/m}^2$$

$$D = 1.88 \text{ cm}$$

$$t = 1.2 \text{ cm}$$

$$\rho = 913 \text{ kg/m}^3$$

$$S_f = 2$$

→ Find sag



(2)

$$d = \frac{w_e L^2}{8T}$$

$$T = \frac{T_u}{S_f} = \frac{8100}{2} = 4050 \text{ Kg}$$

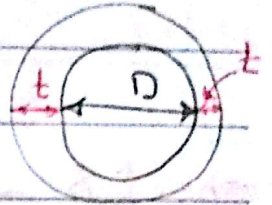
$$w_e = \sqrt{(w_c + w_i)^2 + w_w^2}$$

$$w_w = 38 \times 1.88 \times 10^{-2} = 1.626 \text{ Kg/m}$$

$$w_i = \rho_{ice} \times \text{Area} = 913 \times \left[ \frac{\pi}{4} (D + 2t)^2 - \frac{\pi}{4} D^2 \right] = 1.66 \text{ Kg/m}$$

$$\therefore w_e = 2.524 \text{ Kg/m}$$

$$\therefore d = 4.86 \text{ m}$$



5- Not in sheet)

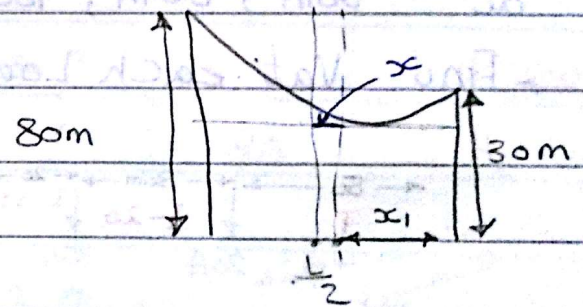
$$L = 450 \text{ m}$$

$$T = 1500$$

$$w_e = 1.4 \text{ Kg/m}$$

→ Find ① min clearance

② clearance at mid point



→ Clearance: is the distance between the cond. and the earth - we get it at max sag

$$\textcircled{1} d_1 = \frac{w_e x_1^2}{2T}$$

$$x_1 = \frac{L}{2} - \frac{T \cdot h}{w_e \cdot L} = \frac{450}{2} - \frac{1500 \times 50}{1.4 \times 450} =$$

$$\therefore \text{min clearance} = 30 - d_1$$

$$\textcircled{2} \text{ Clearance} = S = \frac{w_e x^2}{2T} \quad w_e = r \quad T = r$$

$$x = \frac{L}{2} - x_1$$



$$* d = \frac{w_e L^2}{8T}$$

$$T = \frac{T_u}{S_f} = \frac{8100}{2} = 4050 \text{ Kg}$$

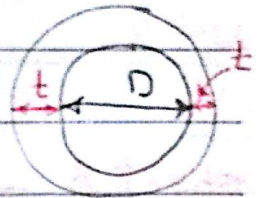
$$w_e = \sqrt{(w_c + w_i)^2 + w_w^2}$$

$$w_w = 38 \times 1.88 \times 10^{-2} = 1.626 \text{ Kg/m}$$

$$w_i = \rho_{ice} \times \text{Area} = 913 \times \left[ \frac{\pi}{4} (D + 2t)^2 - \frac{\pi}{4} D^2 \right] = 1.66 \text{ Kg/m}$$

$$\therefore w_e = 2.524 \text{ Kg/m}$$

$$\therefore d = 4.86 \text{ m}$$



5- Not in sheet)

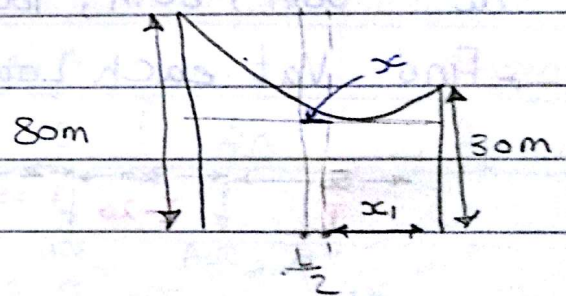
$$L = 450 \text{ m}$$

$$T = 1500$$

$$w_e = 1.4 \text{ Kg/m}$$

→ Find ① min clearance

② clearance at mid point



→ Clearance : is the distance between the cond. and the earth - we get it at max sag

$$\textcircled{1} d_1 = \frac{w_e x_1^2}{2T}$$

$$x_1 = \frac{L}{2} - \frac{T \cdot h}{w_e \cdot L} = \frac{450}{2} - \frac{1500 \times 50}{1.4 \times 450} =$$

$$\therefore \text{min clearance} = 30 - d_1$$

$$\textcircled{2} \text{ Clearance} = S = \frac{w_e x^2}{2T} \quad w_e = r \quad T = r$$

$$x = \frac{L}{2} - x_1$$



## DC distribution

- 2-wire
  - 3-wire
- radial Feeder  
2 ends Feeder  
center Feeder  
Ring

sheet 8 - 1)

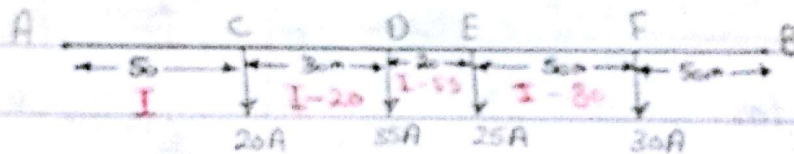
2-wire distributor AB is 200 Long m

R/Conductor/km = 0.4  $\Omega$

Loads: 20 A, 35 A, 25 A, 30 A

at 50 m, 80 m, 100 m, 150 m From A

Find  $V$  at each Load point if  $V_A = 250$  V



$$R_{AC} = \frac{.4 \times 2 \times 50}{1000}$$

$$V_C = V_A - I(R_{AC})$$

$$= 245.6 \text{ V}$$

$$R_{CD} = \frac{0.4 \times 2 \times 30}{1000}$$

$$V_D = V_C - (I-20) R_{CD}$$

$$= 243.44 \text{ V}$$

$$R_{DE} = \frac{.4 \times 2 \times 20}{1000}$$

$$V_E = V_D - (I-55) R_{DE}$$

$$= 242.56 \text{ V}$$

$$R_{EF} = \frac{.4 \times 2 \times 50}{1000}$$

$$V_F = V_E - (I-80) R_{EF}$$

$$= 241.36 \text{ V}$$

$$R_{FB} = \frac{.4 \times 2 \times 50}{1000}$$

$$I = 20 + 35 + 25 + 30 = 110 \text{ A}$$



## DC distribution

- 2-wire radial Feeder
- 3-wire 2 ends Feeder
- center feeder
- Ring

sheet 8 - 1)

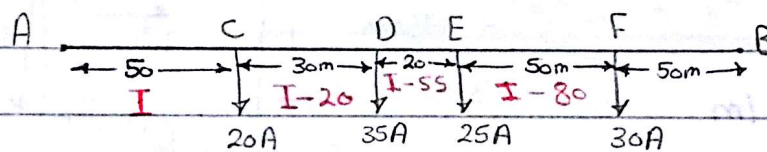
2-wire distributor AB is 200 Long m

R/Conductor/km = 0.4  $\Omega$

Loads: 20A, 35A, 25A, 30A

at 50m, 80m, 100m, 150m From A

→ Find V at each Load point if  $V_A = 250$  V



$$R_{AC} = \frac{0.4 \times 2 \times 50}{1000} =$$

$$V_C = V_A - I(R_{AC})$$

$$= 245.6 \text{ V}$$

$$R_{CD} = \frac{0.4 \times 2 \times 30}{1000} =$$

$$V_D = V_C - (I-20) R_{CD}$$

$$= 243.44 \text{ V}$$

$$R_{DE} = \frac{0.4 \times 2 \times 20}{1000} =$$

$$V_E = V_D - (I-55) R_{DE}$$

$$= 242.56 \text{ V}$$

$$R_{EF} = \frac{0.4 \times 2 \times 50}{1000} =$$

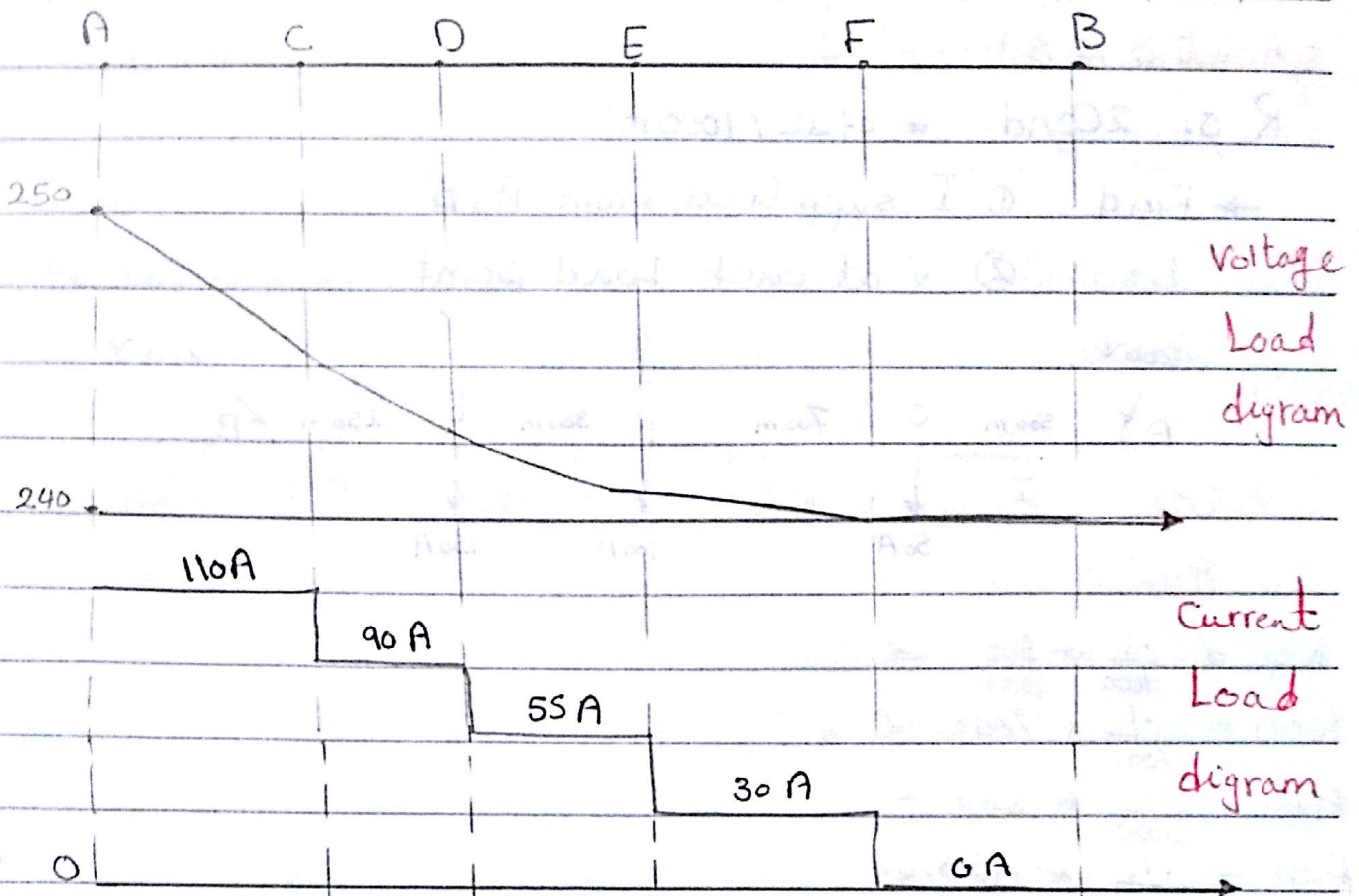
$$V_F = V_B = V_E - (I-80) R_{EF}$$

$$= 241.36 \text{ V}$$

$$R_{FB} = \frac{0.4 \times 2 \times 50}{1000} =$$

$$\rightarrow I = 20 + 35 + 25 + 30 = 110 \text{ A}$$





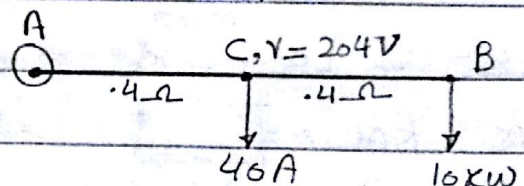
sheet 8 - 2)

DC Line has resistance of  $0.8 \Omega$

- A Load of  $10 \text{ kW}$  at the forend

- Load of  $40 \text{ A}$  at mid point with  $204 \text{ V}$

→ Find supply voltage



$$P_B = V_B (I - 40)$$

$$= [V_C - (I - 40) \times 0.4] (I - 40)$$

$$10^4 = [204 - 0.4I + 16] (I - 40)$$

$$\therefore I = 94.94 \text{ A}$$

$$V_A = V_C + I(0.4) = 204 + 94.94(0.4)$$

$$= 241.97$$



(5)

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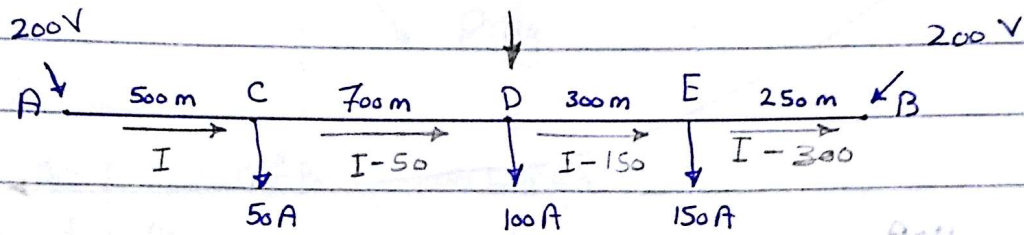
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sheet 8 - 3)

R of 2Cond. =  $0.1 \Omega / 1000 \text{ m}$ 

→ Find ① I supplied from A, B

② V at each Load point



$$R_{AC} = \frac{0.1}{1000} \times 500 =$$

$$R_{CD} = \frac{0.1}{1000} \times 700 =$$

$$R_{DE} = \frac{0.1}{1000} \times 300 =$$

$$R_{EB} = \frac{0.1}{1000} \times 250 =$$

① →

$$V_{AB} = V_A - V_B = 0$$

$$0 = R_{AC}(I) + R_{CD}(I-50) + R_{DE}(I-150) + R_{EB}(I-300)$$

$$\therefore I = I_A = 88.57 \text{ A}$$

$$I_B = -I_A - 300 = 211.43 \text{ A}$$

$$\textcircled{2} V_C = R_{AC} \times I = 195.57 \text{ V}$$

$$V_D = R_{CD} \times (I-50) = 192.87 \text{ V}$$

$$V_E = R_{DE} \times (I-150) = 194.71 \text{ V}$$

A C D E B

200

190

88.57A

38.57

-61.43

-211.43



(5)

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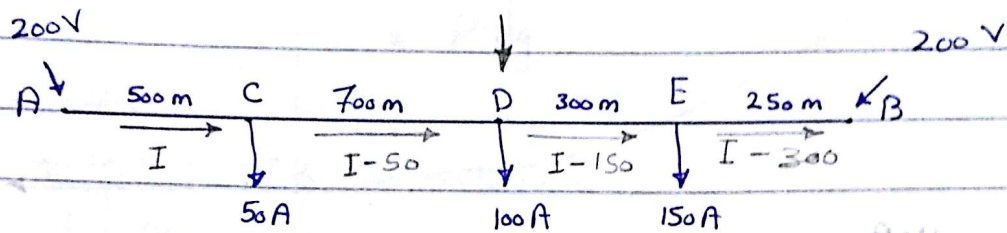
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sheet 8 - 3)

R of 2Cond. =  $0.1 \Omega / 1000 \text{ m}$ 

→ Find ① I supplied from A, B

② V at each Load point



$$R_{AC} = \frac{0.1}{1000} \times 500 =$$

$$R_{CD} = \frac{0.1}{1000} \times 700 =$$

$$R_{DE} = \frac{0.1}{1000} \times 300 =$$

$$R_{EB} = \frac{0.1}{1000} \times 250 =$$

$$\textcircled{1} \rightarrow V_{AB} = V_A - V_B = 0$$

$$0 = R_{AC}(I) + R_{CD}(I-50) + R_{DE}(I-150) + R_{EB}(I-300)$$

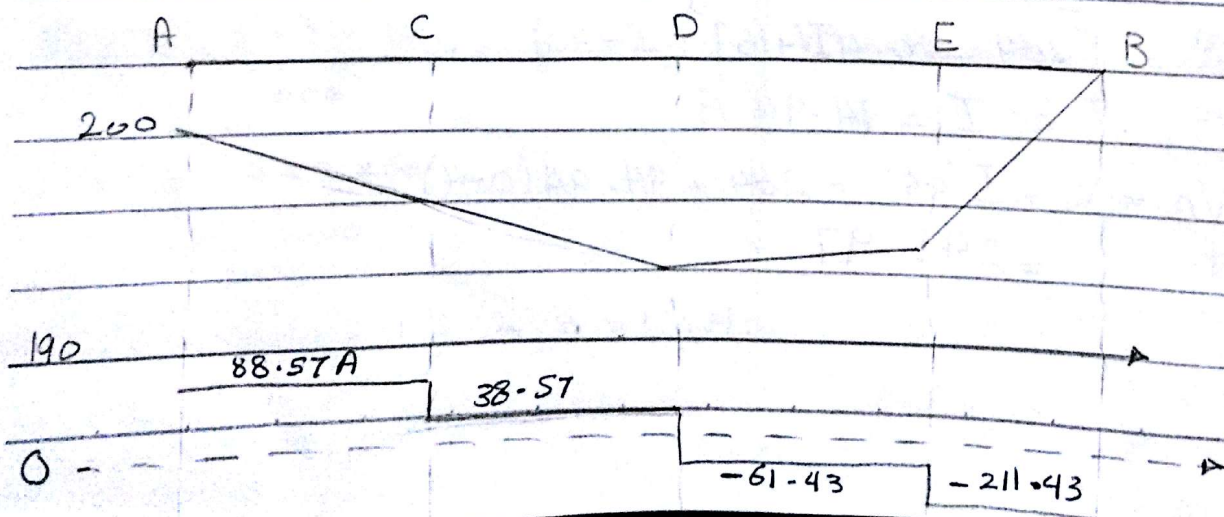
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$$\textcircled{2} V_C = R_{AC} \times I = 195.57 \text{ V}$$

$$V_D = R_{CD} \times (I-50) = 192.87 \text{ V}$$

$$V_E = R_{DE} \times (I-150) = 194.71 \text{ V}$$





(5)

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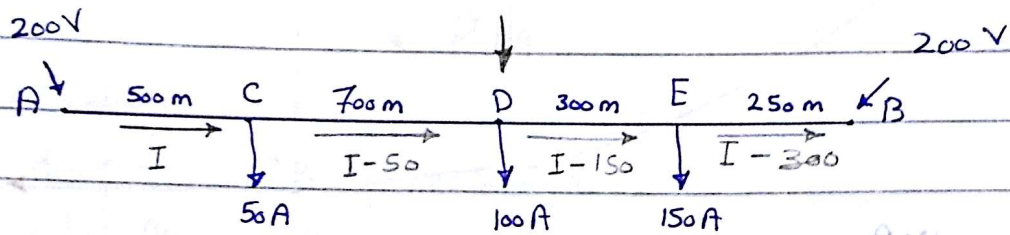
DATE

sheet 8 - 3)

R of 2Cond. =  $0.1 \Omega / 1000 \text{ m}$ 

→ Find ① I supplied from A, B

② V at each Load point



$$R_{AC} = \frac{0.1}{1000} \times 500 =$$

$$R_{CD} = \frac{0.1}{1000} \times 700 =$$

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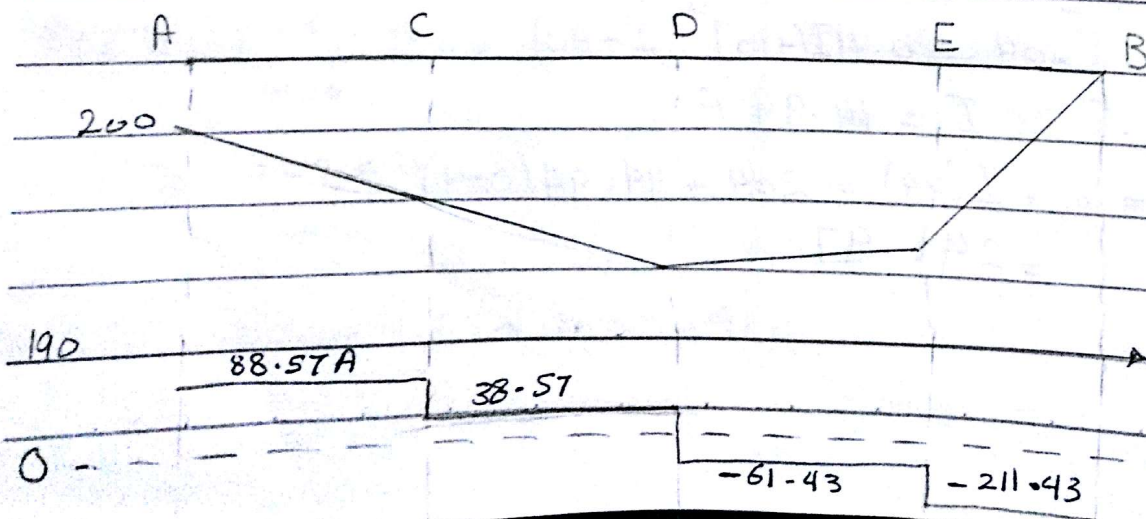
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$$I_B = -I_A - 300 = -211.43 \text{ A}$$

$$\textcircled{2} V_C = R_{AC} \times I = 195.57 \text{ V}$$

$$V_D = R_{CD} \times (I-50) = 192.87 \text{ V}$$

$$V_E = R_{DE} \times (I-150) = 194.71 \text{ V}$$





(5)

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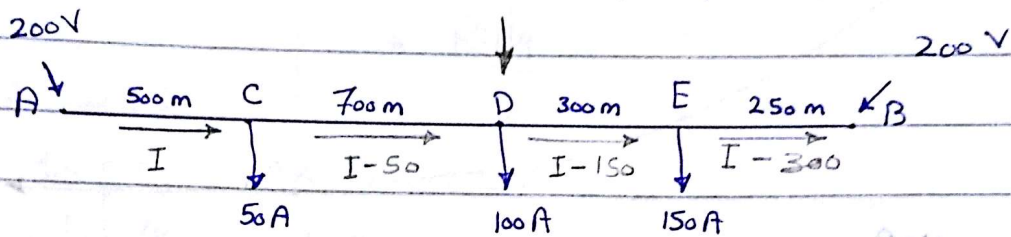
DATE

sheet 8 - 3)

R of 2Cond. =  $0.1 \Omega / 1000m$ 

→ Find ① I supplied from A, B

② V at each Load point



$$R_{AC} = \frac{0.1}{1000} \times 500 =$$

$$R_{CD} = \frac{0.1}{1000} \times 700 =$$

$$R_{DE} = \frac{0.1}{1000} \times 300 =$$

$$R_{EB} = \frac{0.1}{1000} \times 250 =$$

$$\textcircled{1} \rightarrow V_{AB} = V_A - V_B = 0$$

$$0 = R_{AC}(I) + R_{CD}(I-50) + R_{DE}(I-150) + R_{EB}(I-300)$$

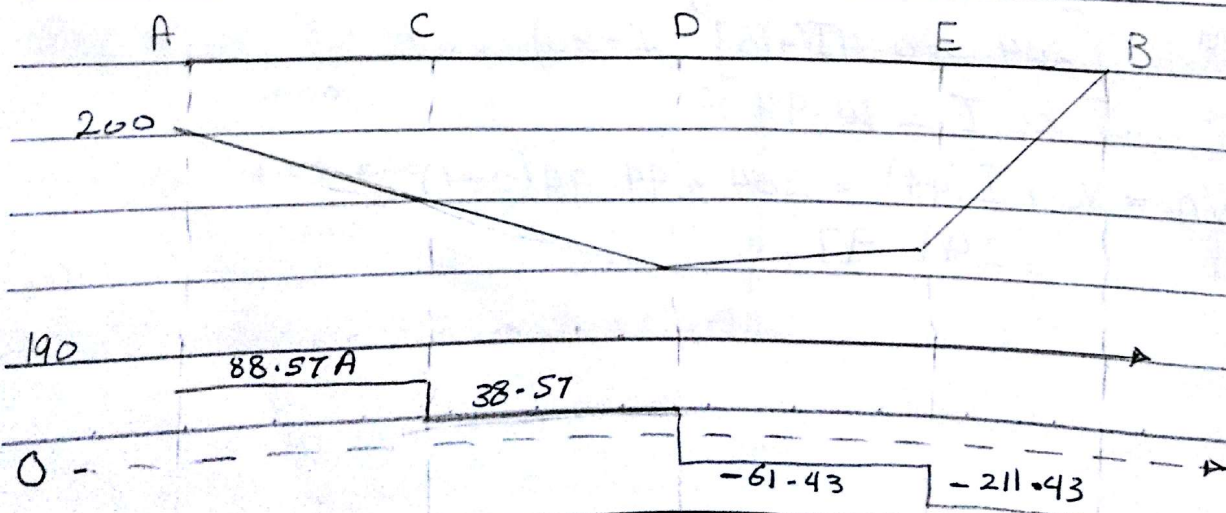
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$$V_E = R_{DE} \times (I-150) = 194.71 \text{ V}$$





Look

Ayat

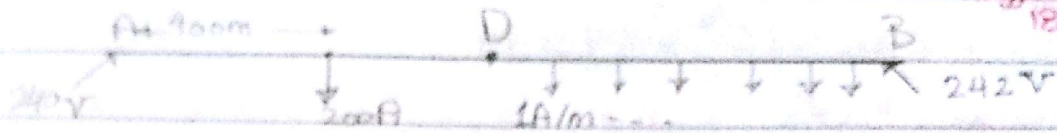
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sec: 8

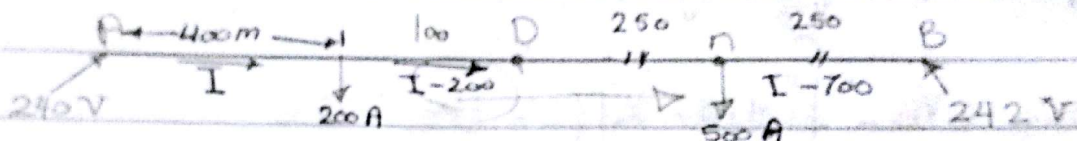
sheet 8 - 5

smile please

18-2-2016



The approximate sol. to consider the uniform distributed loads as one concentrated load.



$$V_{AB} = V_A - V_B = I R_{AC} + (I - 200) R_{CD} + (I - 700) R_{DB}$$

$$240 - 242 = I \left( 2 \times \frac{-0.005}{100} \times 400 \right) + (I - 200) \left( 2 \times \frac{-0.005}{100} \times 350 \right) + (I - 700) \left( 2 \times \frac{-0.005}{100} \times 250 \right)$$

$$\therefore I = 225 \text{ A} = I_A$$

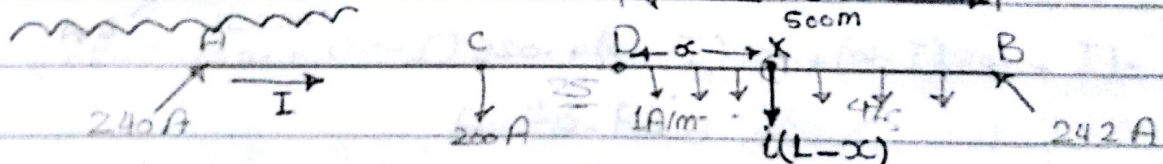
$$I_B = -(I - 700) = -(225 - 700) = 475 \text{ A}$$

point of mini. Voltage  $\rightarrow n$

$$V_n = V_B - I_B R_{nB}$$

$$= 242 - 475 \left( 2 \times \frac{-0.005}{100} \times 250 \right) = 219.4 \text{ V}$$

The exact sol:



$$V_{AB} = V_A - V_B = I R_{AC} + (I - 200) R_{CD} + V_{DB} \quad (1)$$

$$V_{DB} = \int_0^l \left[ I - 200 - (1 \times x) \right] \left( 2 \times \frac{-0.005}{100} \right) dx$$

$$= \int_0^l \left[ I - 200 - x \right] 10^{-4} dx = \boxed{\phantom{000}}$$

بالعوض بالتيه والناسه من الكمال في اللال



Look

Ayat

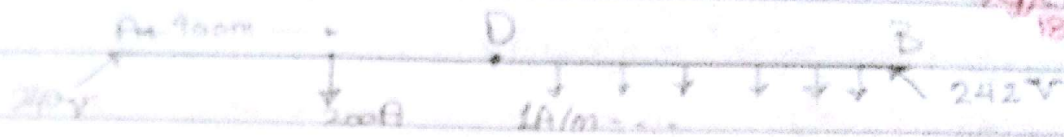
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sec 18

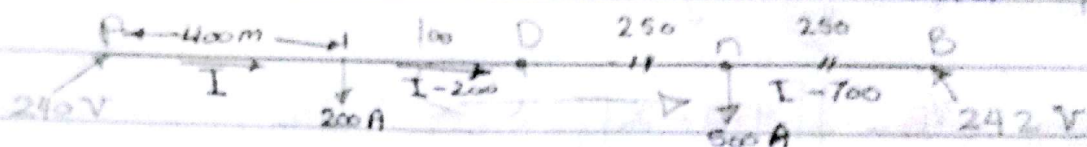
sheet 8 - 5)

emile place. ...

18-2-2016



The approximat sol. to consider the uniform distributed Loads as one concentrated Load.



$$V_{AB} = V_A - V_B = I R_{AC} + (I - 200) R_{CD} + (I - 700) R_{DB}$$

$$240 - 242 = I \left( 2 \times \frac{0.005}{100} \times 400 \right) + (I - 200) \left( 2 \times \frac{0.005}{100} \times 350 \right) + (I - 700) \left( 2 \times \frac{0.005}{100} \times 250 \right)$$

$$\Rightarrow I = 225 \text{ A} = I_A$$

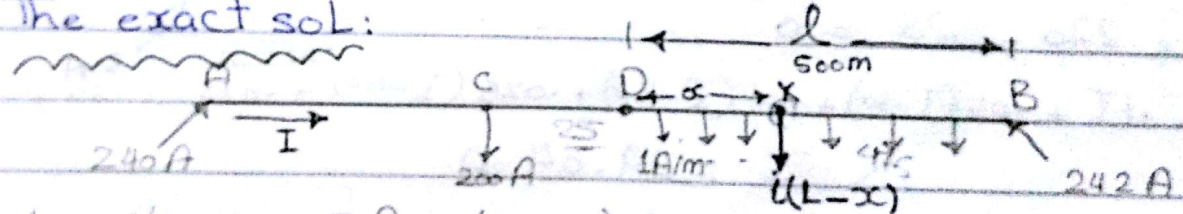
$$I_B = -(I - 700) = -(225 - 700) = 475 \text{ A}$$

point of mini. Voltage  $\rightarrow n$

$$V_n = V_B - I_B R_{nB}$$

$$= 242 - 475 \left( 2 \times \frac{0.005}{100} \times 250 \right) = 219.4 \text{ V}$$

The exact sol:



$$V_{AB} = V_A - V_B = I R_{AC} + (I - 200) R_{CD} + V_{DB} \quad (1)$$

$$V_{DB} = \int_0^{100} [I - 200 - (1 \times x)] \left( 2 \times \frac{0.005}{100} \right) dx$$

$$= \int_0^{100} [I - 200 - x] 10^{-4} dx = \boxed{\phantom{000}}$$

① بالتعويض بالقيمة الناتجة من التكامل في المعادلة



Look

Ayot

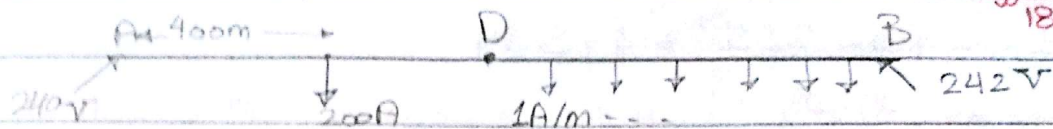
(6)

sec: 8

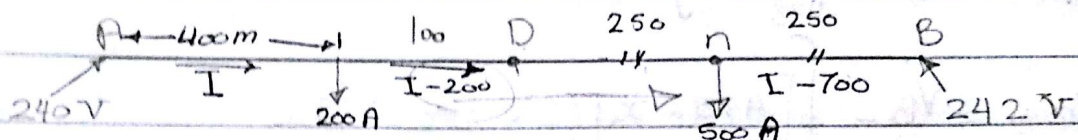
sheet 8 - 5)

smile please. \* حاجة \* دي بي اهم حاجة \*  
الصحة

18-12-2016  
12-12-2016



The approximat sol. to consider the uniformed distributed loads as one concentrated Load.



$$V_{AB} = V_A - V_B = I R_{AC} + (I - 200) R_{cn} + (I - 700) R_{nB}$$

$$240 - 242 = I \left( 2 \times \frac{-0.005}{100} \times 400 \right) + (I - 200) \left( 2 \times \frac{-0.005}{100} \times 350 \right) + (I - 700) \left( 2 \times \frac{-0.005}{100} \times 250 \right)$$

$$\therefore I = 225 \text{ A} = I_A$$

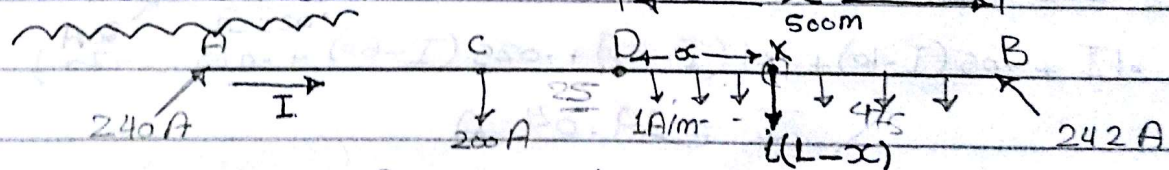
$$I_B = -(I - 700) = -(225 - 700) = 475 \text{ A}$$

point of mini. Voltage  $\rightarrow n$

$$V_n = V_B - I_B R_{nB}$$

$$= 242 - 475 \left( 2 \times \frac{-0.005}{100} \times 250 \right) = 219.4 \text{ V}$$

The exact sol:



$$V_{AB} = V_A - V_B = I R_{AC} + (I - 200) R_{CD} + V_{DB} \quad (1)$$

$$V_{DB} = \int_0^L [I - 200 - (1 \times x)] \left( 2 \times \frac{-0.005}{100} \right) dx$$

$$= \int_0^{500} [I - 200 - x] 10^{-4} dx = \boxed{\phantom{000}}$$

بالعودة بالقيمة الناتجة من التكامل في المعادله (1)



Look

Ayot

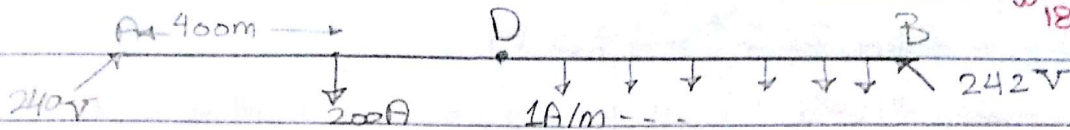
(6)

sec: 8

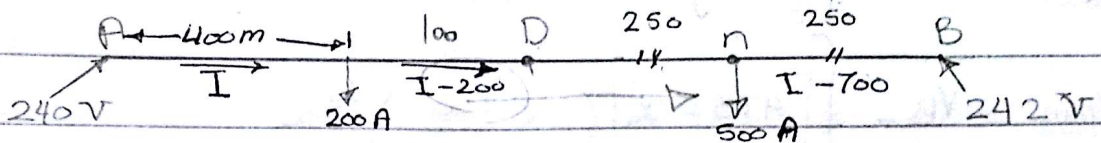
sheet 8 - 5)

smile please. \* حاجة \* دي بيح اهم حاجة \*  
الصحة

18-8-2016



The approximat sol. to consider the uniform distributed Loads as one concentrated Load.



$$V_{AB} = V_A - V_B = IR_{AC} + (I - 200)R_{cn} + (I - 700)R_{nB}$$

$$240 - 242 = I \left( 2 \times \frac{0.005}{100} \times 400 \right) + (I - 200) \left( 2 \times \frac{0.005}{100} \times 350 \right) + (I - 700) \left( 2 \times \frac{0.005}{100} \times 250 \right)$$

$$\therefore I = 225 \text{ A} = I_A$$

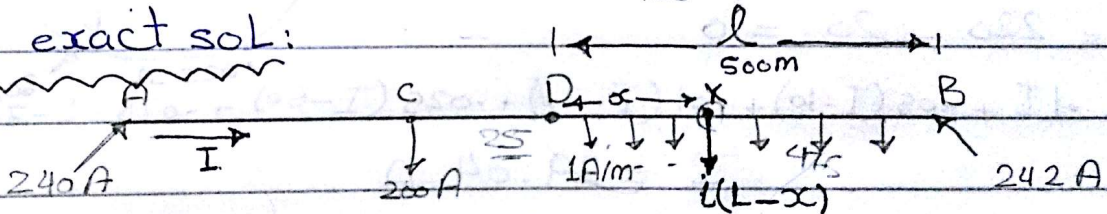
$$I_B = -(I - 700) = -(225 - 700) = 475 \text{ A}$$

point of mini. Voltage  $\rightarrow n$

$$V_n = V_B - I_B R_{nB}$$

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The exact sol:



$$V_{AB} = V_A - V_B = IR_{AC} + (I - 200)R_{CD} + V_{DB} \quad (1)$$

$$V_{DB} = \int_0^{500} [I - 200 - (1 * x)] \left( 2 \times \frac{0.005}{100} \right) dx$$

$$= \int_0^{500} [I - 200 - x] 10^{-4} dx = \boxed{\phantom{0000}}$$

بالعوض بالقيمة الناتجة من التكامل في المعادلة ①



(7)

PAGE

DATE

$$I = 225 \text{ A} = I_A$$

$$I_B = 700 - 225 = 475 \text{ A}$$

Line will be 0, will get line down will be 0

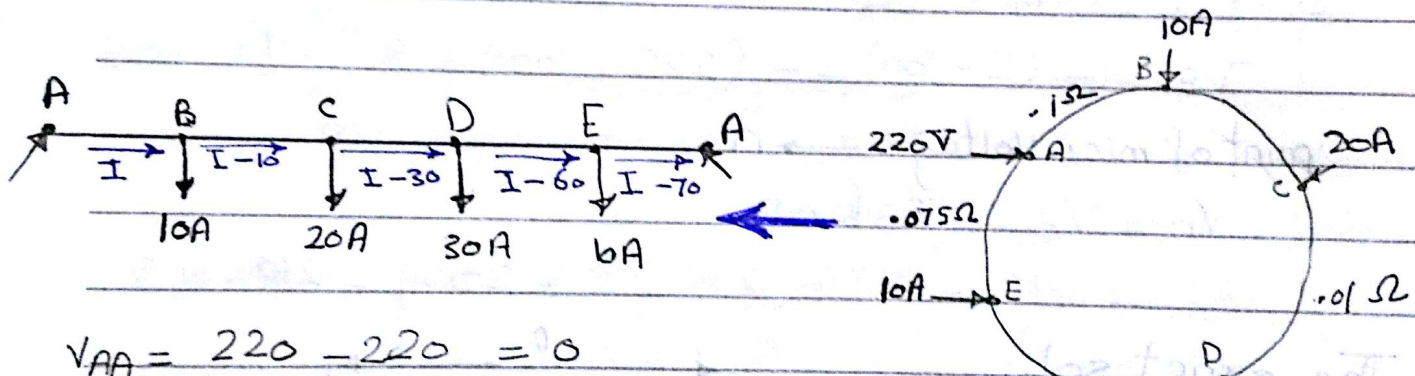
mini voltage

point of mini voltage : at 475 From B

$$V_{\text{mini}} = V_B - \int_0^{475} [475 - x] \left( 2 \times \frac{-0.05}{100} \right) dx$$

$$= 242 - 10^{-4} \left[ 475x - \frac{x^2}{2} \right]_0^{475} = 230.72 \text{ V}$$

sheet 8-6)



$$V_{AA} = 220 - 220 = 0$$

$$0 = 0.1I + 0.05(I-10) + 0.01(I-30) + 0.025(I-60) + 0.075(I-70)$$

$$I = 29.04 \text{ A}$$

$$I_{AB} = 29.04$$

$$I_{BC} = 19.04$$

Point of mini voltage  $\rightarrow$  C

$$I_{CD} = -0.96$$

$$I_{DC} = -30.96$$

$$I_{DA} = -40.96$$

$$V_C = V_A - I R_{AB} - R_{BC}(I-10)$$

$$= 216.144 \text{ V}$$



(7)

PAGE

DATE

$$I = 225 \text{ A} = I_A$$

$$I_B = 700 - 225 = 475 \text{ A}$$

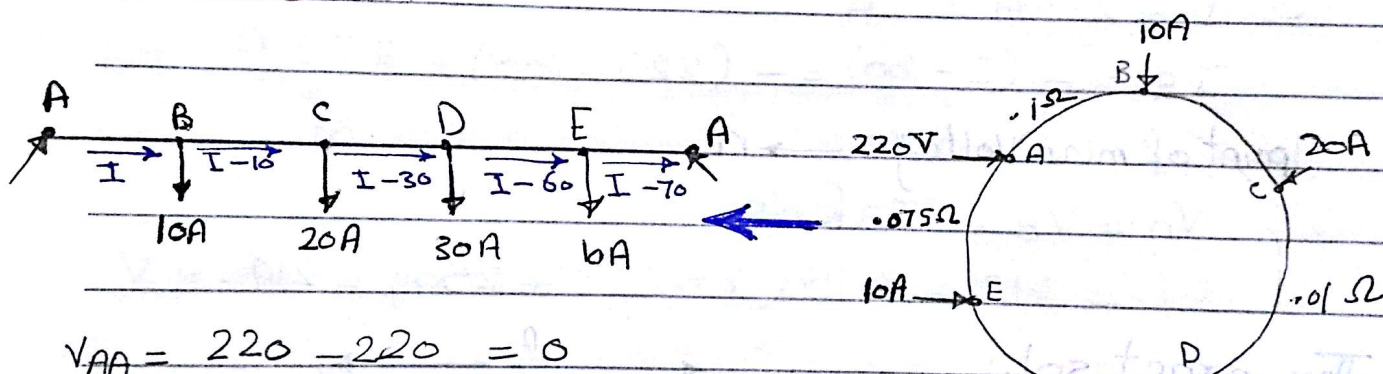
النقطة التي يكون فيها الجهد الأدنى  
mini voltage

point of mini voltage : at 475 From B

$$V_{\text{mini}} = V_B - \int_0^{475} [475 - x] \left( 2 \times \frac{-0.05}{100} \right) dx$$

$$= 242 - 10^{-4} \left[ 475x - \frac{x^2}{2} \right]_0^{475} = 230.72 \text{ V}$$

sheet 8-6)



$$V_{AA} = 220 - 220 = 0$$

$$0 = 0.1I + 0.05(I-10) + 0.01(I-30) + 0.025(I-60) + 0.075(I-70)$$

$$I = 29.04 \text{ A}$$

$$I_{AB} = 29.04$$

$$I_{BC} = 19.04$$

$$I_{CD} = -0.96$$

$$I_{DC} = -30.96$$

$$I_{DA} = -40.96$$

$$V_C = V_A - I R_{AB} - R_{BC}(I-10)$$

$$= 216.144 \text{ V}$$

Point of mini voltage  $\rightarrow C$



PAGE  
DATE

$$I_B = 700 - 225 = 475 \text{ A}$$

point of mini Voltage : at 475 From B

$$V_{\text{mini}} = V_B - \int_0^{200} [475 - x] \left( 2 \times \frac{-\cos x}{100} \right) dx$$

$$= 242 - 10^{-4} \left[ 475 - \frac{x^2}{2} \right]_0^{475} = 230.72 \text{ V}$$

$$V_{AA} = 220 - 220 = 0$$

$$0 = .1I + .05(I - 10) + .01(I - 30) + .025(I - 60) + .075(I - 70)$$

$$I = 29.04 \text{ A}$$

$$I_{AB} = 29.04$$

IBC = 19.04

$$I_{CD} = -.96$$

IDC = -30.96

$$IDA = -40.96$$

$$V_C = V_A - I R_{AB} - R_{BC}(I - I_0)$$

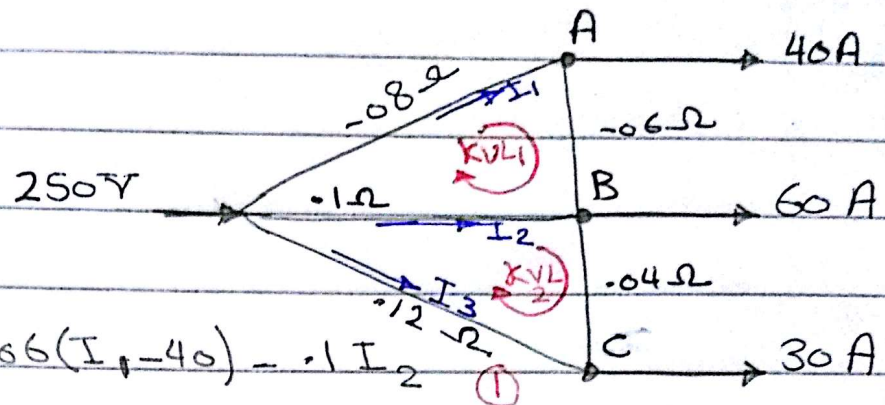
$$= 216.144 \text{ V}$$

$$= 216.144 \checkmark$$

Point of mini voltage  $\rightarrow C$



sheet 8-7)



KVL 1

$$0 = I_1(-0.08) + -0.6(I_1 - 40) - 0.1 I_2 \quad (1)$$

KVL 2

$$I_2(-0.1) - (I_3 - 30)(0.04) - I_3(-0.12) = 0 \quad (2)$$

KCL at B

$$(I_1 - 40) + I_2 + (I_3 - 30) = 60 \quad (3)$$

solving the 3 equations.

$$I_1 = 44.3 \quad I_2 = 45.05 \quad I_3 = 35.56$$

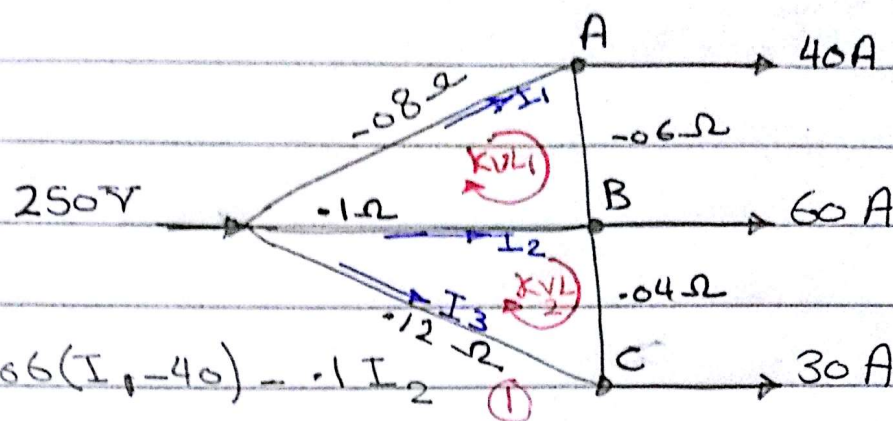
$$V_A = 250 - I_1 \times 0.08 = 246.056$$

$$V_B = 250 - I_2 \times 0.1 = 245.5$$

$$V_C = 250 - I_3 \times 0.12 = 245.7$$



sheet 8-7)



KVL 1

$$0 = I_1(-0.08) + -0.06(I_1 - 40) - 0.1I_2 \quad (1)$$

KVL 2

$$I_2(-0.1) - (I_3 - 30)(-0.04) - I_3(-0.12) = 0 \quad (2)$$

KCL at B

$$(I_1 - 40) + I_2 + (I_3 - 30) = 60 \quad (3)$$

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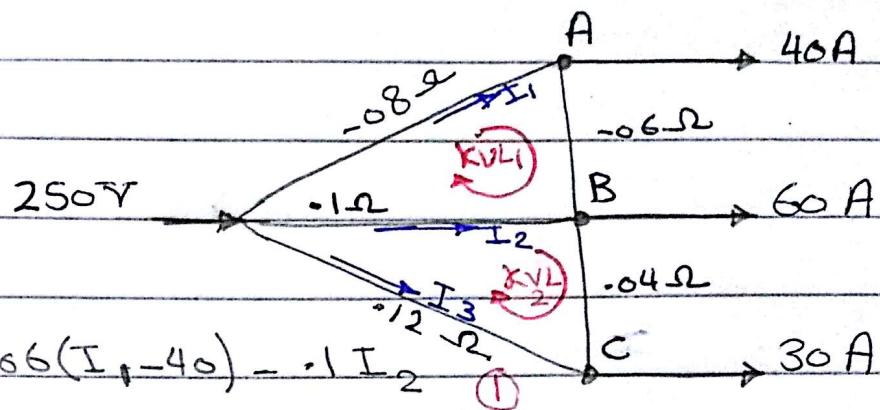
$$V_A = 250 - I_1 \times -0.08 = 246.056$$

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$$V_C = 250 - I_3 \times -0.12 = 245.7$$



sheet 8-7)



KVL 1

$$0 = I_1(-0.08) + -0.6(I_1 - 40) - .1 I_2 \quad (1)$$

KVL 2

$$I_2(-.1) - (I_3 - 30)(.04) - I_3(-.12) = 0 \quad (2)$$

KCL at B

$$(I_1 - 40) + I_2 + (I_3 - 30) = 60 \quad (3)$$

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$$I_1 = 44.3 \quad I_2 = 45.05 \quad I_3 = 35.56$$

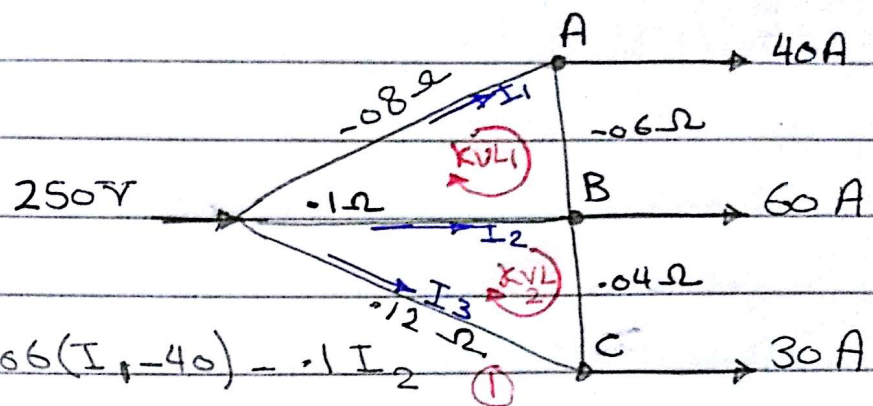
$$V_A = 250 - I_1 \times 0.08 = 246.056$$

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sheet 8-7)



KVL 1

$$0 = I_1(-0.08) + -0.06(I_1 - 40) - 0.1I_2 \quad (1)$$

KVL 2

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